Aino Hatakka & Jarmo Vehmas (editors)

SUSTAINABLE FUTURES IN A CHANGING CLIMATE

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CONTENTS

FOREWORD

How does climate change influence our understanding of the future? How can we contribute to creating desirable but possible futures in the era of climate change?

The Finland Futures Research Centre's 16th Annual International Conference 'Sustainable Futures in a Changing Climate' focused on presenting current future-oriented research on different aspects of climate change, and thus, the conference contributed to the global field of knowledge sharing concerning climate change. Futures studies provide tools and methods to produce future oriented research on the present, to draft possible futures - and even to contribute in shaping the future. The Finland Future Research Centre's Annual International Conference provides a discussion arena for this work.

The conference was held in collaboration with Messukeskus in Wanha Satama, Helsinki on 11–12 June 2014. It was organized as "Future Infinite Academic" in parallel with business-oriented "Future Infinite" (12–13 June). Together these two conferences targeted a broad audience and provided a forum for presentations and other exchanges of ideas and experiences among researchers, students, corporate leaders and decision-makers.

The conference was honored by the presence of Mr. Pekka Haavisto, Minister for International Development who welcomed the participants to the event. The conference had six high level keynote speakers, who all had a focus on climate change in their speeches from different viewpoints: President Tarja Halonen and IPCC Chairman Dr. Rajenda Kumar Pachauri, as well as Prof. Sohail Inayatullah, Prof. Ying Chen, Prof. Joyeeta Gupta, and Prof. Markku Wilenius.

The Future Infinite Academic conference gathered together 140 participants from 21 different countries. During the two days, altogether 67 presentations were held in 11 thematic working groups dealing with the following topics.

- Forests and Climate Change: From Global Trends to Local Landscapes
- Institutional Analysis and Energy Transitions
- North-South Research Collaborations – For Whom and For What?
- Climate Change and Corporate Actions
- Arctic Futures 2033 – Opportunities and Threats for Sustainability
- Climate Change Mitigation Opportunities in Rural Futures
- Climate Governance in the South: Policies and Politics in Mitigation and Adaptation
- Urban Adaptation in a Changing Climate
- Urban Sustainability
- Reasons and Implications of Climate Change
- Methodological and Theoretical Perspectives to Climate Change and Futures Studies

This conference proceedings collects some of the full conference papers presented in the thematic working groups. The articles in this publication are divided to chapters according to the themes of the working groups.

Each article in this conference proceedings has gone through a peer review process. We thank all the authors of the articles and the anonymous referees for their valuable contribution to this publication.

Slides of keynote speeches and workshop presentations held in the Finland Futures Research Centre's 16th Annual International Conference 'Sustainable Futures in a Changing Climate' are available at the conference website www.futuresconference.fi/2014.

In Tampere January 20th, 2015

Aino Hatakka & Jarmo Vehmas

FORESTS AND CLIMATE CHANGE: FROM GLOBAL TRENDS TO LOCAL LANDSCAPES

New and Enhanced Policy Measures for the Sustainable Use of Natural Resources in Agriculture and Forestry

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In this paper, new and enhanced climate-motivated policy measures for the sustainable use of natural resources are investigated using the Delphi method. The objective is to examine the desirability and feasibility of six novel policy measures relating to agriculture and forestry. The measures are 1) a subsidy for land consolidation for expanding farms; 2) obligatory farming of perennial grasses on organic soils; 3) an expansion of the feed-in tariff system of biogas; 4) an investment subsidy for manure handling; 5) a revised taxation system for private forestry; and 6) a reallocation of forestry subsidies from timber production to public goods such as recreation and biodiversity. The Delphi study was carried out in two rounds of an online questionnaire. On the first round 174 experts evaluated the policy measures according to a prepared evaluation framework. After considering a summary of the first round results, 74 experts provided revised responses on the second round. As a conclusion the potential of each measure is analysed according to the evaluation framework. In the analysis quantitative results are complemented with the experts' qualitative argumentation.

Introduction and Background

The sustainable use of renewable natural resources in the face of climate change requires legitimate, inclusive and effective governance (Lockwood et al. 2010). In the multi-level governance system, grassroot-level actions are influenced by internationally framed and nationally defined policy measures and their application in subnational levels. Policy renewal in agriculture and forestry involves considering a wide variety of policy instruments affecting farmers' and forest owners' investment and land use decisions. These decisions often have long-run impacts, which are sensitive to changes in the operational environment; thus futures orientation is elementary when designing and imposing new policy instruments.

The purpose of this paper is to define and evaluate a balanced set of new or enhanced policy measures in order to make a stable transition towards more sustainable use of renewable natural resources. The policy measures, representing forestry and agricultural production systems, aim to balance between sustainability, cost-efficiency, and acceptability. The evaluation is done with the aid of an expert panel and a two-round Delphi questionnaire.

The research questions are defined as follows:

- How does the panel of experts holistically rate the desirability of the primary aims and the implementation (means) of six novel policy measures relating to agriculture and forestry?
- How do the experts rate the cost-efficiency of the measures?

- What are the main supporting and opposing arguments relating to the sustainability impacts and cost-efficiency of the measures?

Material and Methods

When the Delphi method was introduced, it was considered as a version of a survey analysis (Bell 1997). The first applications focused on seeking a consensus on technical topics among homogeneous groups of experts. Since the 1970's the aims of the Delphi method have been diversified and several variants have been added to the Delphi method family. The variants alongside conventional Delphi are the Policy Delphi and the Argument Delphi (Turoff 1970, Linstone & Turoff 1975, Kuusi 1999, Tapio 2002).

The Delphi method concentrates on assessing and forecasting the future. The users of the Delphi technique explore alternative future images, possibilities, their probabilities of occurrence, and their desirability by tapping into the expertise of respondents (Bell 1997). In the method, information is obtained from experts through questionnaires and interviews, after which the information is revised with one or more additional rounds of information gathering. Prior to a new round of answers, the experts are informed of the results of the previous round. This allows individual experts to position themselves in relation to the opinions of the group of experts.

In this study a mixed approach of conventional type and policy type of two-round Delphi was conducted. Conventional approach refers to extensive amount of respondents in the panel. The policy Delphi in this study refers to an approach in which in addition to convergence of opinions, also dissent or non-convergence was sought and examined.

The Delphi process was conducted as follows:

1. Preparation of the new policy measures according to recent policy discussions and literature regarding agriculture and forest policy (alternatives for current policy tools)
2. In parallel to new measures, a policy evaluation framework was adopted from earlier literature (Vedung 1997, Mickwitz 2006) and refined for the base of expert evaluation
3. A selection criteria for choosing experts were defined (a large panel of experts, policy stakeholders and interest groups)
4. Conducting the first round questionnaire with the expert panel
5. Presenting the first round results to the panel and acquiring second round responses
6. Drawing conclusions of the desirability and feasibility of the evaluated policy measures

We examined six policy measures (Table 1). Four of the measures targeted agriculture and two of them targeted forestry. The researcher group defined the measures on the basis of recent national-level policy documents on agriculture and forestry with the aid of four criteria: 1) the main aims are compliant with broad policy targets; 2) each measure contains at least one type of policy innovation that is not currently in use in the sector; 3) the set of measures includes various types of policy tools (regulations, subsidies, taxes), and 4) the set of measures targets different sections of the sector broadly. Most of the policy measures were designed to foster ecological sustainability. The policy measures targeting agriculture focused on methods to decrease greenhouse gas (GHG) emissions. In addition to climate objectives, some of the measures had a broader ecological aim. The reallocation of forestry subsidies targeted several ecosystem services and farms' land consolidation subsidy was designed to improve the control on several environmental impacts such as land clearing and farm traffic. In addition to ecological sustainability, all these measures aimed to promote forestry and agriculture based livelihoods. Especially one of the measures, the revision in forestry taxation system, focused more strongly on economic and social sustainability. The revision of forest taxation aims at improving forest owners' economic opportunities by increasing the profitability of their wood sales. All the measures are further described with their primary aims in Table 1.

Table 1. A description of the assessed policy measures. The order of the measures follows the order in the questionnaire.

Policy measure	Primary aim	Instrument
An expansion of the feed-in tariff system of biogas	Decrease the GHG emissions from agriculture by directing underutilized manure and grass into biogas production by which the use of fossil fuels can be replaced.	To accompany the investment subsidy currently in force, feed-in tariff system would be introduced for biogas plants that are under 100kVa. The price certainty would increase the farm operated biogas plants' profitability.
Obligatory farming of perennial grasses on organic soils	Decrease the GHG emission originating from organic soils.	Set obligation to farm perennial grasses and thus reduce the need for soil preparations on organic soils.
A revised taxation system for forestry	Increase the activity of forest owners towards wood sales.	An implementation of a forest owners' choice in taxation. The forest owners can periodically choose between the current taxation system that is based solely on the net proceeds and a combination of taxation systems. In the combination, the taxation consists partly of a lowered tax rate of the current taxation and partly by an area-based taxation. The combination of the taxation systems increases the forest owner's economic benefit by the harvest opportunities he exploits.
A subsidy for the land consolidation for expanding farms	Promote livestock farms' use of cultivated land especially on areas where there is an increasing trend for clearing organic soil lands for cultivation.	An introduction of a spatially allocated subsidy that is directed to the owner of the cultivated land. The subsidy activates the land owner to initiate land consolidation with active farmers. Land consolidation would shorten the distances among land parcels and thus decrease the traffic.
An investment subsidy for manure handling	Increase the recycling of nutrients and thus decrease the nutrient load by the closed nutrient cycle procedure.	An investment subsidy given for farms to purchase the best available technology approved and specified by the administration. The subsidy would promote farmers to invest into the newest and most efficient emission reduction technology.
A reallocation of forestry subsidies from timber production to public goods such as recreation and biodiversity	A combination of 1) strengthening the forest owners' entrepreneurship, 2) increasing the market governance in forestry and 3) allocation of subsidies from timber production to goods and services that lack a market value (e.g. biodiversity, carbon storage, recreation).	A deduction in the subsidies for timber production by lowering the level of compensations, tightening the terms and limiting the purposes the subsidies are given for. A redirection of subsidies based on environmental and other externalities produced by forests.

The selection of the panel is a critical phase in using methods like Delphi technique (Kuusi 1999). According to Kuusi (1999) the Delphi facilitator should consider in his/her actor analysis the most important stakeholders and interest groups, most important substance (the competence of experts) as well as the terms of delivering information in a Delphi process (information policy). The selection process of an expert panel should be done as transparent as possible.

In this study the selection process proceeded as follows. First, the criteria for choosing experts were prepared according to the research goals. In principle, the experts were expected to have some background on climate change, renewable energy, and/or agriculture and forestry processes. An expertise matrix was prepared in order to select a balanced respondent panel. The decisive selection dimensions were 1) expertise and educational background and 2) actor group i.e. professional perspective on natural resource utilization. The former classification contained agriculture, forestry, climate change, renewable energy, economics, social science in general, technological and natural sciences; and the latter classification contained research and education, primary production, administration, NGO's, agricultural and forestry extension, interest groups, industry and trade. The research group listed the preliminary panellists and their expertise classifications, and the final respondents were selected together so that all classification dimensions were represented in the panel.

In preparing the questionnaire an evaluation framework was defined to capture the dimensions that policy evaluation literature (e.g. Vedung 1997, Mickwitz 2006) considers important when assessing the implementation of a policy measure. These dimensions were namely 1) the advocacy of the measure's implementation (means); 2) the advocacy of the measure's primary aim; 3) the cost-efficiency of the measure; 4) the foreseen timing of the measure's possible implementation, 5) the measure's sustainability impacts, and 6) the impact of alternative economic growth to implement the measure. In this paper the first three dimensions and some open-ended arguments are analysed and presented.

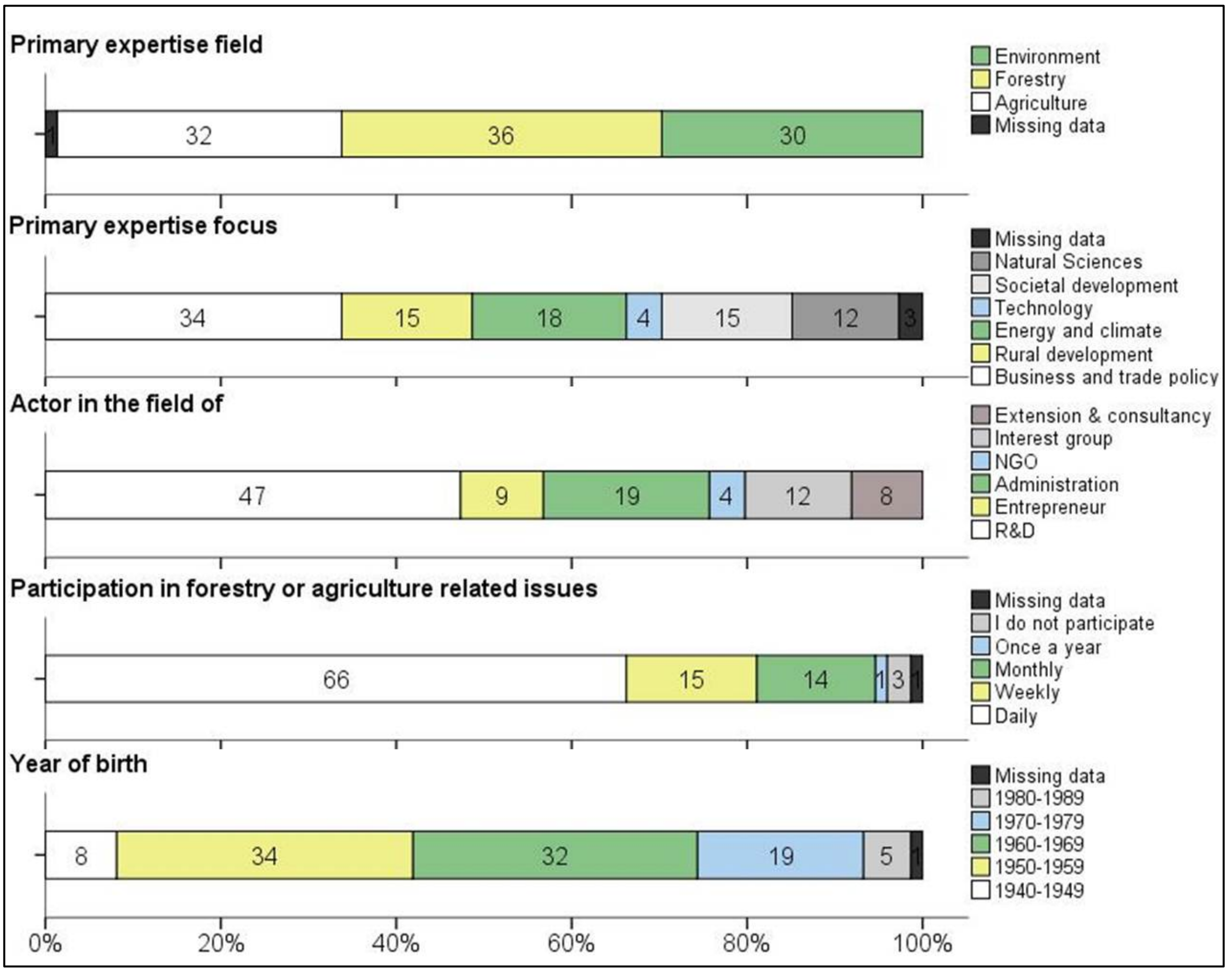

Figure 1. The expertise of the second round Delphi respondents (n=74).

The first round empirical data was gathered in September 2013. The expert panel consisted of 571 respondents of which 174 responded (response rate 30.5%). The second round was organized in January 2014 and it was targeted to those who answered the first round questionnaire. The second round panel consisted of 174 panellists and 74 of them (42.5%) responded to the questionnaire (Figure 1). Before asking the panellists to re-evaluate the 1) advocacy of the measure's implementation (means), 2) advocacy of the measure's primary aim, and 3) cost-efficiency of the measure, we asked them to take a stand on five arguments picked from the first round open answers.

The open-ended arguments were generated as follows. On the first round questionnaire, open-ended responses were prompted separately for the cost-efficiency and for the sustainability impacts of the measures. In the latter case the respondents were given the power to focus on any aspect that they felt important under the term sustainability. However, before prompting this question, sustainability was framed in the questionnaire by first asking the experts to rate their views on the sustainability impacts on ecological, economic, and socio-cultural dimensions. Under these dimensions, sustainability was operationalized into the aspects of biodiversity, water system, climate, EU-compatibility, administrative easiness, profitability of businesses, rural livelihood, landscapes, and the performance of networks. The cost-efficiency and sustainability responses were merged and qualitatively analysed, yielding relevant opinion patterns for each measure. From these opinion patterns, a few argument sentences, representing both positive and negative views on the measure, were formulated to be rated on the second round questionnaire.

Results

The presented results are based on the three evaluation dimensions that were asked from the panellists, namely 1) the advocacy of the policy measure's implementation i.e. means (Figure 2); 2) the advocacy of the measure's primary aim (Figure 3); and 3) the cost-efficiency of the measure (Figure 4). Each figure shows the distribution of the responses on the first and second rounds of the questionnaire.

In general the share of extreme opinions declined from the first to the second round with respect to all three evaluation dimensions. The respondents supported the aims of the measures more than the means of the measures (Figures 2 and 3). The experts approached the cost-efficiency of the measures more critically (Figure 4). The rankingof the policy measures according to the second round mean ratings was the same in all three evaluation dimensions.

The advocacy of the investment subsidy for manure handling increased a little on the second round from the first round (Figure 2). There was a lot of support to an argument claiming that theprocessing of manure and handling methods will help particularly big farms to command growing manure amounts.

The advocacy of the subsidy for land consolidation declined clearly from the first round. There was notable support to the given argument claiming, based on the open-ended responses in the first round questionnaire, that the existing field renting system should preferably be enhanced instead of land consolidation practice. Moreover, some of the respondents saw that the market forces should direct the land consolidations preferably than subsidies.

The advocacy of the expansion of the feed-in tariff system of biogas also declined from the first round. Many of the respondents accepted the given argument that "Distributed renewable energy production and the use of bioenergy must be promoted from the perspective of larger scale systems [than a scale of a single farm]".

The advocacy of expanding the obligatory farming of perennial grasses on organic soils declined slightly from the first round. The respondents placed some support to the argument that some of the organic soils should rather be transferred to wood-based biomass cultivation or reforested than obligated to cultivate perennial grass on them.

The advocacy of the revised taxation system for private forestry declined slightly from the first round. There was some support to the given argument stating: "the measure would only benefit the forest owners that are already active in wood sales and thus would not affect the wood sales".

The panel's opinion pattern on the reallocation of forestry subsidies smoothened from the first round: the share of two highest supporting classes declined from 38% to 18% and the share the two least supporting classes declined from 32% to 18%. There was some support to the arguments that reallocating these subsidies would decrease timber production and furthermore, affect negatively on forestry and rural development in general.

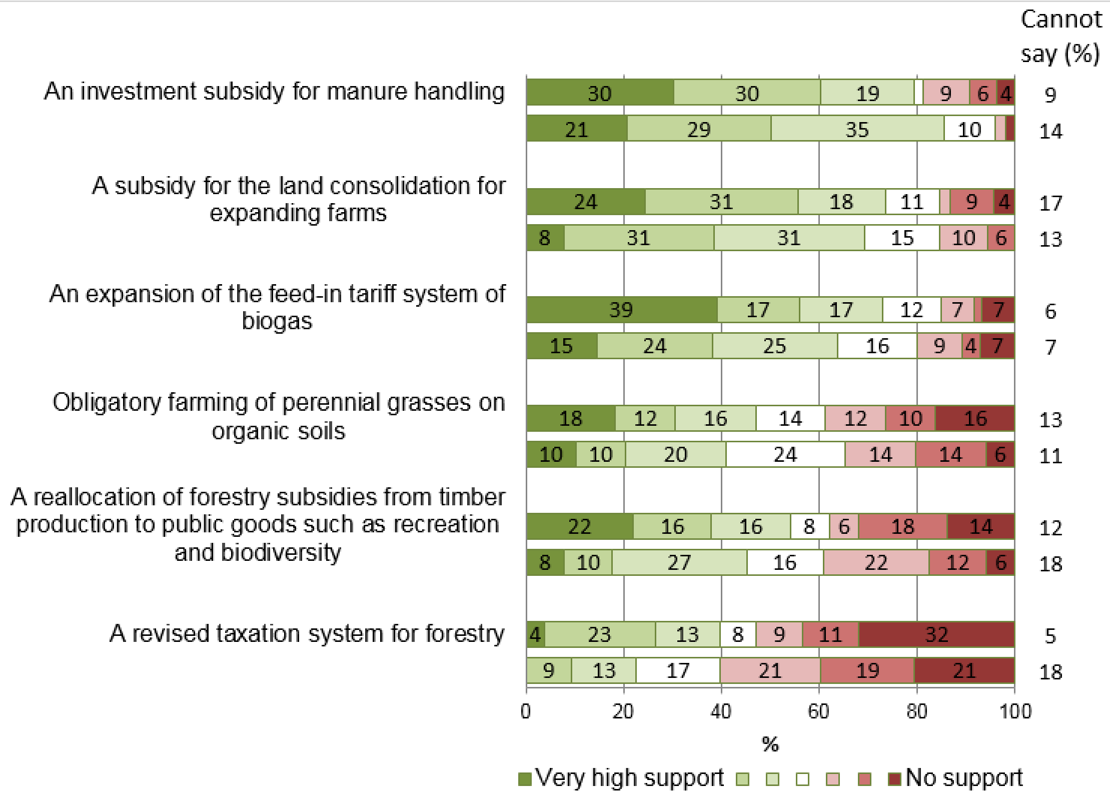

Figure 2. The response distribution of the advocacy of the measures' implementation (means). The upper bars: the first round; the lower bars: the second round. The stacked bar numbers sum up to 100%; the Cannot say percentages are shares among all respondents.

The investment subsidy for manure handling's primary aim received received generally a bit more more support slightly fewer extreme opinions on the second round than on the first round (Figure 3). Closed nutrient cycle procedure was seen as important on both of the rounds. The panel placed support on the argument that manure is expected to have a higher value in future due to the scarcity of nitrogen and phosphorus.

The subsidy for land consolidation's primary aim also received less extreme response distribution on the second round. It appears that the respondents had rather stable understanding of the measure's intended benefits for the environment and farm economy. According to supported argumentation it can rationalise farm logistics, and therefore also increase well-being of entrepreneurs by shortening distances between fields.

The advocacy of the primary aim of expanding the feed-in tariff system of biogas declined from the first round. The respondents placed support on the given argument that by the current knowledge on using manure and grass as raw material of biogas, plants cannot achieve major GHG emission reductions in relation to the investment.

The opinion pattern concerning the obligatory farming of perennial grasses on organic soils' primary aim became smoother on the second round. Some of the respondents supported the argument that this kind of measure is sensible to reduce GHG emissions, but then some respondents wrote that if the primary aim is to reduce GHG emissions and there is no use for the grass it would be more sensible to reforest (carbon sink).

The advocacy of the primary aim of the revised taxation system for private forestry was the lowest comparing all the measures and declined further on the second round. However, the share of extreme opinions declined on the second round. Some respondents supported the arguments stating that the current demand for wood material does not require an increase in the supply and on the other hand, increasing the activity in wood sales would threaten the forests' ecological sustainability.

The advocacy of the primary aim of reallocating forestry subsidies declined slightly on the second round and resulted in a relatively low rating. The respondentsplaced some support on the arguments that other forms of forest use do not need subsidies, because the forests under orindary forestry offer good enough possibilities for recreational use. Meanwhile, other respondents claimed that the dependence between timber production and subsidies should be minimised.

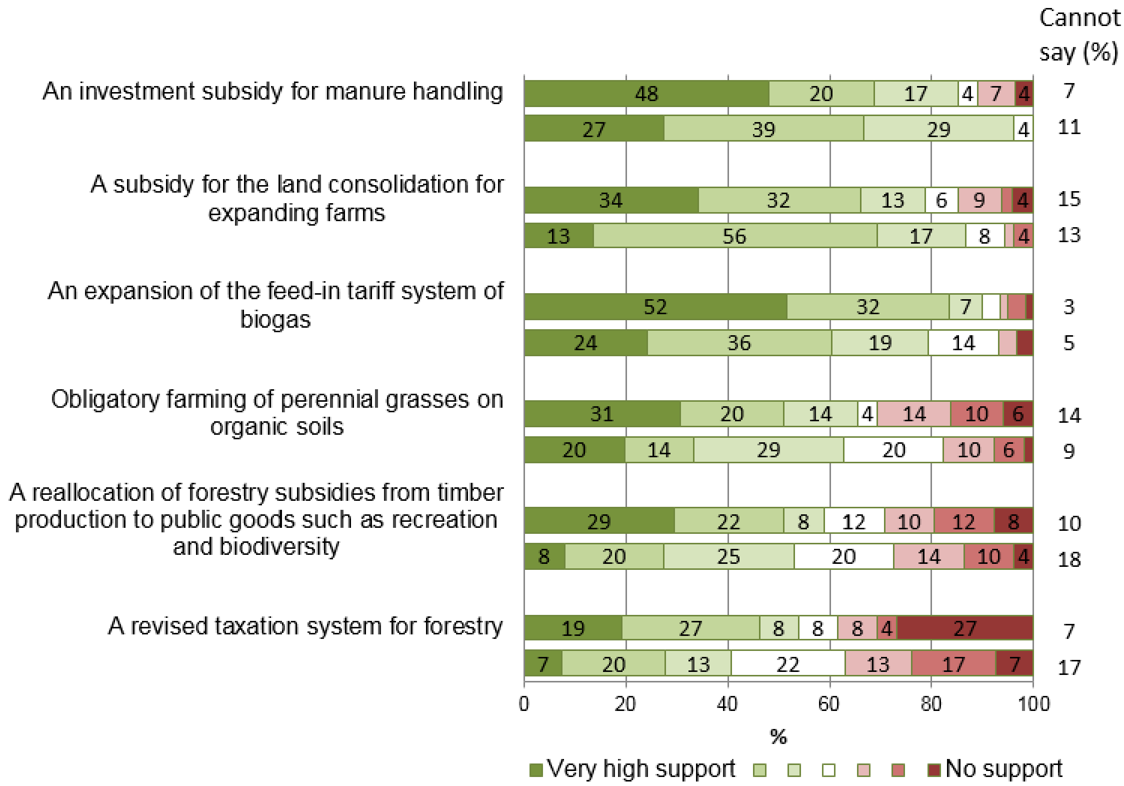

Figure 3. The response distribution of the advocacy of the measures' primary aims. The upper bars: the first round; the lower bars: the second round. The stacked bar numbers sum up to 100%; the Cannot say percentages are shares among all respondents.

The cost-efficiency rating for the investment subsidy for manure handling slightly declined from the first round but was still high. Some respondents supported the given arguments implying that this kind of measure is necessary because of the forthcoming restrictions of nutrition limits. The cost-efficiency rating for the subsidy for land consolidation declined from the first round. The respondents generally opposed the given argument "The societal benefit from the land consolidation is small, so there is no use to promote it by additional subsidies". Some of the respondents also considered the cost-efficiency of this measure to rise in the long run.

The cost-efficiency rating for expanding the feed-in tariff system of biogas declined clearly from the first round to the second. The respondents placed support on the argument "Managing agriculture by product flows are very important to the environment in the future (synergies e.g. manure storing, benefits of vegetations, nutrient cycle)". The cost-efficiency rating for the obligatory farming of perennial grasses on organic soils received less support and more doubts on the second round. The respondents generally supported the argument "Obligated cultivation of something that might lack a demand does not seem to be cost-efficient".

The cost-efficiency of the revised taxation system for private forestry was rated low and it decreased even further on the second round, although the share of the most negative views declined. The measure was seen to demand high administrative and bureaucratic investments and thus it was feared to be expensive. Additionally, the effectiveness was expected to be low as the measure was only seen to activate those forest owners who are already active. The cost-efficiency of reallocating forestry subsidies was seen more positively than the cost-efficiency of the revised forest taxation system. Yet, it decreased clearly on the second round. The supported arguments highlighted the importance of the timber production subsidies for forest owners and rural areas. According to some arguments, cutting all the subsidies was considered cost-efficient.

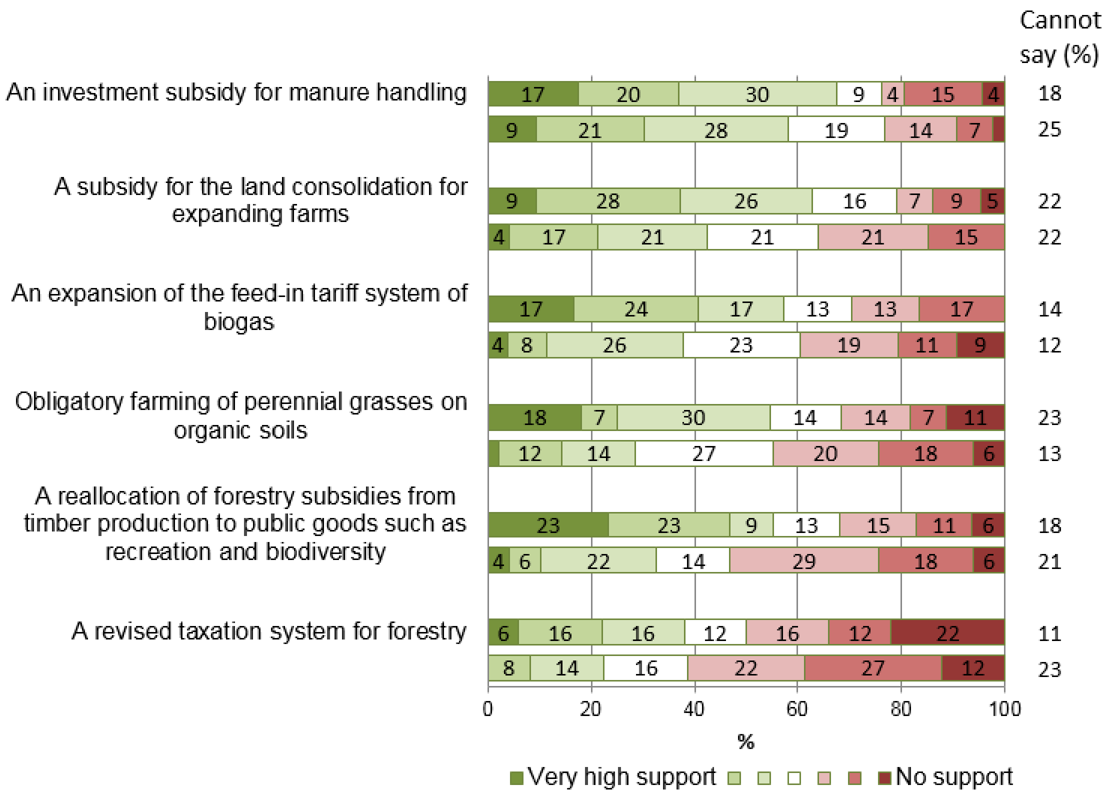

Figure 4. The response distribution of the cost-efficiency of the measures. The upper bars: the first round; the lower bars: the second round. The stacked bar numbers sum up to 100%; the Cannot say percentages are shares among all respondents.

Discussion and Conclusions

In this paper a balanced set of new or enhanced policy measures were investigated with the Delphi method in order to make a smooth transition towards more sustainable use of renewable natural resources. The main goal was not only to evaluate the advocacy of the proposed measures themselves but also to evaluate the primary aim behind the measures as well as the cost-efficiency of each measure.

The desirability of the investment subsidy for manure handling was the highest among the six measures, both in terms of its primary aims and its implementation. The experts also evaluated this measure as the most cost-efficient and considered it feasible. The experts' arguments indicate that when making the measure operational one should pay attention to the specific means of targeting and granting the subsidies.

The subsidy for the land consolidation for expanding farms was also rated relatively high in the same three dimensions. The possible implementation of the measure involves technical and administrative challenges that need to be solved in further preparations and development projects.

The primary aim and implementation of expanding the feed-in tariff system of biogas were seen quite desirable, but attention should be paid to the scale of the system built around the biogas. Operationalisation of the measure requires careful preparation of its cost-efficiency and supervision. The obligatory farming of perennial grasses on organic soils was considered to be a good measure by its promising potential to reduce GHG-emissions, but in the future reforestation should be considered as an alternative. Moreover, the subsidy level and its effectiveness should be critically examined in further studies.

The revised taxation system for private forestry gained the lowest support in all the three assessed dimensions when compared to the other measures. The demand for the primary aim, i.e. increasing the supply of timber, was seen questionable. Moreover, part of respondents placed importance on the ecological sustainability, which, according to their views would not be improved by implementing this measure. Some other respondents emphasized that the forest taxation system needs to be more simple, stable and predictable.

Overall, the desirability of the policy measures dealing with forestry (taxation and reallocation of subsidies) was rated quite low. These results may reflect the controversial nature of tax reforms and the suggested overhaul of the entire forestry subsidization system. As for the presented tax reform for forestry, an added feature in this study are the likely complex and subtle impacts of a such reform which the panellists most likely had difficulties assessing of. This implies that possibly other means than online questionnaires could be used when assessing in detail the impacts of such delicate and complex policy instruments. Therefore it is suggested to complement the online questionnaire results with third round Delphi with expert interviews along with quantitative evidence from modelling exercises.

The current forestry subsidy system was seen to be outdated but opinions diverged concerning the direction where the subsidies would be needed. Experts from natural and social science background placed higher support on this measure while administration experts placed lower support i.e. they wanted to hold on to the current subsidies. A striking difference between all the assessed forestry and agriculture measures was the stronger polarisation in the opinions concerning the forest measures. This difference may indicate larger disagreements on the forestry sector or that the forest measures presented newer or more radical ideas, which were not discussed publicly before this assessment, leading to critical initial view linked with a lack of comprehension. A further reason may be that the measures targeting on agriculture business are generally associated with fewer conflicting interests compared with the multiple and diverse values that relate to the private and public use of forests.

The rating results revealed an interesting pattern: all the aims of policy measures were rated notably higher than the possible implementation of the measures. This indicates that there are disagreements regarding the effectiveness of the measures. It is therefore evident that the practical impacts of the measures need to be more thoroughly studied in the future in order to identify desirable and feasible policy changes. As another interesting pattern was that the order of the measures based on the received support remained the same in all three evaluation dimensions. It may be that the respondents were not able to distinguish very well between the aim of the measure, its means and its cost-efficiency, resulting in more or less holistic evaluation. Some respondents even commented that without more detailed information it is hard to evaluate the effects of the measures. When continuing to use the three dimensions in policy surveys, clarifications are evidently needed.

Third interesting pattern in the results was the weaker polarisation of the opinions on the second round compared to the first round (Figures 2–4). This may be due to the arguments that were shown to the respondents on the second round. Since the arguments aimed to present both the positive and negative aspects gathered from the first round open-ended responses, it is possible that after going through the arguments, the respondents adopted an intermediate view between the pros and cons. This overall opinion of the panel indicates that the measures are neither accepted nor rejected as such but require further investigations. It has also been noted in the literature of Delphi studies that the deviation in answers from first to second round tend to decrease.

In this study the evaluation of the policy measures was based on the chosen expert panel evaluation. Because the main goal of the study was to examine the advocacy of the investigated new measures, any numerical impact assessments were not done beforehand for the use of Delphi rounds. In principle such assessments presented together with the used questionnaire could bring new insight also to experts and affect also the views of panellists. Also the experts would have been able to compare and evaluate the measures between each other, for example with the aid of more in-depth cost-benefit analysis. In this study the value of this type of Delphi study on new or enhanced policy measures is in our opinion three-fold. First, the Delphi procedure provided advice for targeting further research on the performance and effectiveness of the measures. Second, it helped to identify problematic issues that may be later used in dialogue among experts and stakeholders about the desirable and other alternative future paths towards sustainability, which is fundamental to inclusive participatory governance. Third, it yielded important preliminary material to working groups that will in future be responsible for preparing policy renewal reports for governmental decision-making.

Acknowledgements

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Responsive Governance in Climate Change Adaptation and Mitigation: Participatory Land Use Planning in Angai Forest, Southeast Tanzania

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There is a need to better understand better how governance related to climate change is revealing itself in different developing country contexts in which governance in general is facing challenges. Adaptation and mitigation strategies, like REDD, offer a possibility for conserving forests and mitigating the effects of climate change. According to the United Republic of Tanzania's REDD Strategy lack of land use plans is one of the drivers of deforestation and forest degradation in Tanzania, which in turn are remarkable drivers of climate change. As of this writing, Participatory Land Use Planning (PLUP) is on-going in 24 villages in Angai Forest, Southeast Tanzania. The aim of this research is to determine how responsive governance is manifest in PLUP in Angai and what types of impacts and effects PLUP has on responsive governance. In this article governance is studied through the concepts of decision-making, rights, responsibility and accountability. According to this study, PLUP in Angai has positively enhanced the implementation of laws, rules and guidelines emphasizing public participation, but in reality, donor funding has also hampered the genuine participation.

Introduction and Background

The literature on eco-social dependency is dominated by international considerations and institutions, whereas the regional and local aspects of it are less researched. Citizens at the local level require alternatives to make choices, perform experiments in the social organization of actions and in this way produce new ecologically sustainable societal innovations that governments are reluctant to produce (Häilä 2009). In the anthropocene[1] era, participatory and deliberative governance approach is necessary; such an approach would create public space and strengthen democracy from below. Successful and sustainable environmental management and even environmental rehabilitation is possible only when active local level support exists (Bliss & Neumann 2008, 6–17).This article argues that action space for citizens is necessary to develop our societies sustainably; this process can be enhanced through responsive environmental governance. Local residents cannot, and often do not, offer solutions to their environmental challenges, nevertheless, the potential of grassroots environmental action and participation of locals has been unjustifiably neglected. The ways in which people protect and cope with the changing environment can only advance the search for sustainable development (Ghai & Vivian 1992). This study contributes to the less-researched local aspects of eco-social dependency.

Environmental development interventions such as REDD+ seek also to function as a form of governance. Reducing Emissions from Deforestation and Forest Degradation (REDD) is an effort to create a financial value for the carbon stored in forests, offering incentives for developing countries to reduce emissions from forested lands and invest in low-carbon paths to sustainable development. "REDD+" goes beyond deforestation and forest degradation, and includes the role of conservation, sustainable management of forests and enhancement of forest carbon stocks." (The United Nations Collaborative Programme on Reducing Emissions from Deforesta-

[1] Anthropocene is the current geological age, a period during which human activity has been the dominant influence on environmental and also on climate (e.g. Rockström et al. 2009).

tion and Forest Degradation in Developing Countries 2013.) For example in REDD+ a particular problem concerns how a changing environment and its solutions are framed, validating and legitimizing specific tools, actors and solutions while marginalizing others.Public participation captures how REDD+ attempts to establish participatory and responsive environmental governance by aligning the interests of a wide range of stakeholders in the process create desired environmental outcomes. (Thompson, Baruah & Carr 2011.). Deforestation and forest degradation are two remarkable drivers of climate change (Burgess et al 2010: 341). According to the national climate change adaptation and innovation strategies, such as the United Republic of Tanzania's REDD Strategy (2012) on driver of deforestation and forest degradation, in turn, is the lack of land use plans. Consequently, the development of such plans has been made a prerequisite for REDD. PLUP is important for identifying strategies to reduce forest degradation and for creating associated incentives, as well as regenerating forests on fallow agricultural lands, thereby increasing carbon sink capacity (Bourgoin et al 2013). PLUP process can also build decision-making capacity at village level. The government of Tanzania (see the Land Act 2002 and the Village Land Act 1999) supports and recommends that PLUP be conducted in all villages throughout the country. It is supposed to help communities to make informed choices and decisions on land allocations and land management in sustainable way adapting and mitigating to the changing climate.

The current regional and local governance structure in Tanzania has its roots in villigization process (ujamaa). During the 1970s, the government approved legislation to support village governance revitalizing Village Assemblies (which include all adults in the village) and Village Councils (15–25 elected representatives and a Village Chairman) to organize the rural population and to materialize the principle of subsidiarity – transmitting central development plans to the community level (The Villages and Ujamaa Villages Act 1975; The Local Government Act 1982). The Local Government Reform Programme of 1990 also sought to transfer resources from the central to local government (Tidemand & Msami 2010). Individual development programs, such as RIPS (Rural Integrated Participatory Support funded by Finnish Government) also introduced participatory methodologies for planning and implementation, thereby contributing to the democratization processes (Nsa-Kaisi 1998). As a result of its history and legal reforms, Tanzania has one of the most resilient local institutional frameworks for natural resource management based on community decision-making in sub-Saharan Africa (Blomley & Iddi 2009, 11). Despite various reforms to local government, local governance continues to face the challenges of corruption, transparency, responsiveness and participation (Tidemand & Msami 2010).

As of this writing Participatory Land Use Planning (PLUP) is on-going in 24 villages in the vincinity of Angai Forest in the Liwale District of Southern Tanzania. The process is supported by a development cooperation project LIMAS (Lindi Mtwara Agribusiness Support). LIMAS is jointly funded by the Governments of Tanzania and Finland. LIMAS primarily provides technical support and grants to entrepreneurs and business entities to support the development of sustainable and profitable agribusinesses. (LIMAS 2014) Project supports the development of secure land tenure (e.g. PLUP) in order to enhance sustainable use of natural resources. Angai Forest is located in Southern Tanzania within 24 villages in Liwale District occupying a total area of 139,420 hectares. The aim of this research is to study the following two questions: What constitutes responsive governance in the context of the Angai communities? How is responsive governance manifested in PLUP and what types of impacts and effects

PLUP have on responsive governance? In this article, responsive environmental governance is studied through the concepts of decision-making, rights, responsibility and accountability.

Materials and Methods

The research on responsive environmental governance in Angai forest is an on-going project. This paper only represents the preliminary analysis, based on data collected in late 2013 – early 2014. Most of the data gathering for the study was conducted in six villages near Angai forest, Kitogoro, Mtawatawa, Litou, Kiangara, Legezamwendo and Mikunya. Selected villages completed their PLUPs in 2013, and they were approved by the Liwale District Council. In addition to village-level discussions, meetings were held with officials and actors at district, regional and national levels. The methods employed included interviews, focus group discussions and participatory observation. In total 31 individuals were interviewed and two focus group discussions were conducted. Ultimately, 62 people were contacted. A researcher spent six weeks in the intervention area during a period of 14 months. When the researcher was not in the villages or gathering data at the national level, she observed closely the operations at the LIMAS head office, where PLUP was also monitored and supervised.

Focus groups functioned well for exploring mutual experiences and identities, such as, what it means to be a woman in a forest-dependent community, how the community participates in village decision-making in general, and how local governance is structured. However, certain voices may be silenced during group discussions and certain hierarchies emerge. This is an important considerations in settings in which research participants have on-going social relationships that may be compromised by public disclosure and where the dominant culture does not equally support the participation of all. The interviews permitted a deeper analysis, not only of the character of life but also the feelings associated with an individual's participation or lack thereof, in village decision-making. In addition, the interviews also represented an opportunity to raise sensitive issues. The interviews were used to explore the views, experiences, beliefs and motivations of individual participants, whereas the focus groups were used understand group dynamics (Michel 1999, 36–41). Individual interviews allowed the possibility to explore respondents' reaction in detail without contamination. Focus group discussions and interviews were conducted in Kiswahili with the aid of a translator. National-level interviews were conducted in English. All discussion material was transcribed verbatim into English.

In addition to the field work, the researcher performed a desk review of the national legal and guiding documentation on land use planning, key LIMAS project documents related to the land use planning process, and relevant reports and studies conducted in the area. The data were primarily analyzed through qualitative textual analysis.

Conceptualizing Responsive Governance

In this research responsive governance is defined through four central concepts. *Decision making* is understood as a process within decentralized governance by which a group or individual chooses one alternative over another regarding an issue or a resource. *Accountability* is that the persons responsible are held to public scrutiny, regarding their performance, decisions and tasks. *Rights* are understood here as enforceable claims, comprising systems that govern access to, e.g., the use of land and forests (MacPherson 1978, and Maxwell and Wiebe

1998, as cited by Ribot 2011). *Responsibility* is a moral agency, a consciousness of possible implications, knowledge, decision-making, and the assumption that the individual or group in question can be considered in determining outcomes. In responsive governance decision-making processes are open among stakeholders; the responsibilities and accountability of a government is well defined, as well as the rights of duty bearers.

In order to understand and describe both the macro and micro levels of administration, formal and informal rules; how governance interventions actually impact representation, results in this paper are presented through vertical and horizontal challenges. These challenges are reflected through Riggs's (1964) theory of prismatism which divides countries roughly to three categories. Least developed countries are fused societies, developed societies are diffracted and the societies in the middle are prismatic. In fused society every institution with the society is responsible for a variety of different activities whereas in diffracted society every institution is specialized just for few functions. Prismatic society is rather dysfunctional having features of both extremes simultaneously. (Riggs 1964: 19–27; cf. Levy 1966: 18.) In prismatic societies administrative systems are transplants of Northern structures; however, in reality, new systems have not replaced but displaced the traditional systems. Also the idea of institutional monocropping by Evans (2004) is used when discussing the reality of responsive governance in Angai. Monocropping in this context refers to the imposition of outlines based on idealized versions of Anglo-American institutions to other countries. In reality, the applicability of these institutions does not transcend national circumstances or cultures. (Evans 2004.) In a nutshell, a vertical challenge is understood as conflicting orders of international, national and local level, materializing into situations where international or national guidance does not reflect on local reality. A horizontal challenge in turn refers to a situation where within a societal system there exists more than one decision making structure side by side.

Results – Horizontal and Vertical Challenges of Responsive Governance

To exploit and manage a forest, communities in Tanzania need to develop forest management and harvesting plans. A land use plan in turn aids the creation of forest management and harvesting plans by categorizing and allocating different uses of land. PLUP process has been divided into six steps in the Guidelines for Participatory Village Land Use Planning Administration and Management in Tanzania (URT 2011): Preparations at district (e.g. to establish a district participatory land use management team and action plan for actual PLUP), to perform Participatory Rural Appraisal (PRA) for land-use management, mapping existing land uses, to conduct the actual participatory land use planning, to create structures for the Village Land Administration (e.g. to establish a district and village land registry, to prepare, register and issue Certificates of Customary Right of Occupancies) and to implement the plan.   Several PLUP related activities have been performed in the Angai area over the years, but PLUP has only recently been completed and officially approved. PRA exercise was conducted in the villages of Mihumo, Ngonja and Ngongonwele in 2009 (Sundström 2010), and partial demarcation of forest without approved management plans in 2001. The Angai community's disappointment with several interventions (including some not related to PLUP) that have not produced the intended benefits poseschallenges for any new intervention, including the on-going PLUP. Despite 20 years of conservation, Angai Forest is still not officially a village reserve, as one Participatory Forest Management (PFM) process has been completed but not officially approved, and proper land use plans and by-laws are only now materializing.

As PFM has not been official , legal harvesting in the area is not financially beneficial for the communities, therefore, illegal harvesting is common. Fragmented support over the years has led to distrust in the community and the discontinuity of the process, which might both in the long-run have contributed to deforestation (see also Dondeyne et al. 1998, Mustalahti 2007). The history of inconsistent support for Angai does not support LIMAS's multi-step approach (PLUP → PFM → harvesting plan) that is intended to eventually to grant communities permission to exploit their resources. At best, the above mentioned steps could contribute to the ending the era of fortress conservation (see below) and secure local residents' property rights. Nevertheless, the public rightly wonders: how this intervention differs from prior attempts, which have not delivered any tangible benefits for the communities.

Angai's communities have suffered from both vertical and horizontal governance challenges. Throughout its history, Angai has suffered from the failure of national or even international strategies and policies to reflect reality at the local level, whether the forced migration of "ujamaa" or donor-funded activities like REDD+ (both vertical challenges). The horizontal challenge of overlapping structures (monocropping, Evans 2004) has caused ineffectiveness and hampered the implementation of responsiveness of governance (prismatism, Riggs 1973). Currently only the official village government structure (Village Council, elected committees, Village Assembly) is recognized, despite the traditional actors, such as chiefs, clan leaders and even religious leaders influence decision making. When discussing the decision making at the village level respondents mentioned that traditional leaders are influential and their views are respected, even to the extent that Village Council cannot make a decision which would contradict the views of traditional leaders. Riggs' (1973) theory of prismatism argues than in societies where more than one decision-making structuresexist side by side none of them works well causing ineffectiveness and confuses processes.

In principle this study strengthened the hypothesis that decision-making structures that allow locally elected representatives to participate in decision-making are more equitable than those in which technical staff employed by national or local government, NGOs, private sector or donors make the decisions. During the PLUP process participants felt that their views were listened to and taken into account when the actual plan was drawn. During the PLUP process villagers have got several opportunities to participate. Village assembly and hamlet meetings are forums of lively discussion. However, like in any public debate certain people (e.g. Village Council members) dominate the discussion and often ordinary villagers remain silent. The draft land use plan is available for everyone to comment at village house. Some argued that previous land use planning processes had been more top down and donor-driven, and thus the implementation of the plans never took place as people did not feel ownership to it. The on-going PLUP process in Angai has promoted participation and inclusion and thus contributed positively to local democracy. PLUP has created more opportunities for individuals at the local level to influence the public debate and even decision-makingAccording to the respondents, the Village Assembly, composed of all adult villagers, has greater influence than it did previously. Village Land Use Plan is approved solemnly by the Village Assembly not e.g. by Village Council which of the case in the village decision making. The above described concrete decentralized management system can promote a broader democratization process in Angai, as prior studies on Tanzania demonstrate e.g. Wily & Dewees (2001) (see also Ribot 2003). Study also confirmed that accountability mechanisms which recognize locally-responsive representation and create offsetting powers through responsibility to, and enforcement by social groups and individuals (e.g. user groups, household heads, individual farmers, women and youth) enhance equitability, enforce accountability and corresponding power in local-level decision-making. Local level decision making structures as well as accountability measures are based on locally elected representatives in Angai communities. Most of the respondents knew and understood accountability measures, nevertheless certain challenges exist. The general public is only learning about their rights and they know them in principle, but to be actually empowered e.g. challenging leaders and to hold them in public scrutiny will take time. Also the existence of overlapping structures creates confusion.

Riggs (1973) theory of prismatism, or overlapping structures, is the reality in Angai. While the structures and positions of traditional leaders were abolished in early 1970 due to ujamaa, they still exist and influence in practice. The official structure of governance is well established, with locally elected representatives as described above. Whereas the role of traditional leaders is not acknowledged in the official structures, and discussing their influence most of the interviewees immediately deny that they have any role in decision making, when discussing concrete decision making situations the influential role of elders, chiefs, clan leaders and religious leaders is mentioned (horizontal gap).

> *"If the views of elected leaders and traditional leaders are conflicting, traditional leaders will always win! You cannot decide on a matter against their will!"* – *National Level Actor* –

Interestingly, in some villages, traditional structures have merged into official structures. For example in Litou, an elders committee was established to solve especially border conflicts as they know the history of their surroundings. This notion of merging structures is desirable in social situation; such as that in Tanzania, where formal and informal structures exist but the latter are not officially recognized. Official co-existence can be beneficial for sustainability and real legitimacy. The traditional leadership institutions are an aspect of the historical heritage of local communities and cannot be eliminated (Blom 2002, Ntsebeza 2003). Creating clear accountability measures and responsibilities for duty bearers in such a setting is, however, challenging. In the case of Angai, instead of discovering new institutional strategies for local governance, the common policy consequence has been institutional monocropping (Evans 2004) which has led to a bifurcated society of overlapping structures, i.e., prismatism (Riggs 1973). Riggs (1973) reasons that such institutional monocropping creates new systems that have not replaced but rather displaced traditional systems. Societies tend to perpetuate many of their most valued ancient traditions and cultural norms while simultaneously importing and accepting a facade of practices and patterns. Two systems co-exist, with neither of them working well (see also Jabbra & Dwivedi 2004). According to this research, this also appears to be the case in certain to extent in Angai communities.

The official co-existence is also not without complexities, as it reinforces less-systematically accountable actors (vs. representative actors) and slows the democratic transition (Ribot 1996). It also likely strengthens certain oppositions: customs vs. rights, representation vs. participation, centralization vs. decentralization, and civil society vs. communities. In the context of such polarization, traditional leadership is perceived as an instrument of oppression in the areas of political organization, women's rights, social mobility and economic rights (Ntsebeza 2003). Despite this criticism, in rural settings such as in Angai, traditional leaders can be far more legitimate promoters of development than elected representatives. According to the findings in Angai, traditional leaders "have got people", they mediate conflicts (especially land conflicts) and are the custodians of traditions. If they are actively ignored they can harm the processes; when they are not ignored, they can take further responsibility for local challenges.

The case of PLUP in Angai confirms the notion that allocating rights and responsibilities to locally-elected representatives and even to villagers expands the public domain and promotes citizenship as a social practice (Sian 2010) in which leaders are held accountable and locals can subject them to public scrutiny. National laws and international regulations can be empowering, and they are a necessary condition for allocating rights and responsibilities to local actors. The challenge, however, is that when national and international decisions, rules and regulations do not reflect the reality at the local level, the gap between policies and local actions remains too wide (vertical gap).

Despite the supportive legal environment and strong local institutional framework coupled with good intentions, previous interventions in Angai have resulted in economic and social losses for villagers by restricting and even preventing their access to the forest without providing adequate compensation, governance has not been responsive. These types of exclusive and coercive approaches to conservation (also termed fortress conservation approaches) have been criticized due to the injustices they have caused and their ineffectiveness (Lele et al., 2010; Brockington et al., 2008; Adams & Mulligan, 2003).

Overall, the PLUP intervention in Angai has been conducted in a fairly democratic and participatory manner, with respect for the subsidiarity principle of making decisions at the lowest possible level. Communities themselves make their land use plans and outsiders are only present for facilitative purposes. Despite the participatory approach in PLUP in Angai, the villager participation has been disappointing. One could argue that in Liwale district some of the principles of decentralization[2] are weakly understood and that the capacities at the district and village level for managing the participatory process are inadequate. The people have access to village decision making through general village assemblies, the village council is elected by the assembly, etc., but villagers are not genuinely interested or their capacity to participate in these events is inadequate. Villagers are illiterate, live in remote areas and are not aware of their rights; occasionally the theme of intervention is overly complex. Individuals might be aware of their rights but not dare to demand them or have access to information but are unable to make sense of it. In particular, the role of women in local democracy is weak and difficult. Women are present in village assembly meetings but they often remain silent. However, land use planning and natural resource management impact the daily lives of women and the well-being of families to greater extent than men, as women use natural resources for household subsistence (food, water, firewood vs. men who use them financial purposes). Even when women and men are present in relatively equal number in every action related to land use in Angai, this presence appears insufficient to achieve gender equality, as Momsen (2004) argues. The challenge is to grant an equal opportunity for all to live a fulfilling life. Momsen (2004) also comments that women's concerns regarding environmental issues are no reflected in their actual political participation. According to this study, women would need education to enhance their confidence and courage to achieve gender equality in the public sphere.

[2] The success of decentralization requires a clear definition of the respective roles of local, regional and national level authorities, paired with development of effective local level institutions for planning and decision-making. Above mentioned institutional arrangements are rarely established in so-called decentralization reforms (Ribot 2003).

Changing the culture of silence for wonmen is a slow process and negative peer pressure (noted also in Angai) from women themselves makes the transformation difficult.

In general, the understanding of land rights, property rights and rights to use natural resources are weak, despite that the legislation is supportive, e.g., many villagers believe that no one benefits from the forest. Only at the ministry level were interviewees able to cite the three most important legal documents regulating and guiding land use planning. Community members in Angai do not understand that allowing illegal harvesters to operate in their forest is not good for the community as whole. Moreover, due to the history and reality of fortress conservation (see above), communities have also accepted the unaccepted to be normal and the only way to benefit from the forest, as property rights are unclear and therefore unsecure. Ultimately, illegal harvesting is a source of income for few villagers.

> *"If only the villagers would understand that illegal harvesters are stealing from them! Letting them harvest is like stealing from your own pocket."   – National level actor –*

The findings described above support the argument advanced by previous studies on grassroots participation; engaging individuals at the local level will involve marginalized persons in processes that they unable to question or influence (Bliss & Neuman 2008). Individuals wish to be heard but their abilities are not necessarily equal to those needed for constructive discussions and decision making. At its worst, decentralization may strengthen the role of local elites, enhance socio-political fragmentation along ethnic lines, marginalize less dynamic regions and weaken national cohesion (OECD 2001, 20). It has been argued (e.g., Hayes & Ostrom 2005), that under certain conditions, local actors and locally elected authorities manage natural resources better than would be the case under centrally controlled approaches. However, in the case of Angai, according to this study, these conditions have not been fully satisfied echoing the findings of many other studies which you might cite in the discussion (see e.g. Ribot et al. 2010) One challenge in Angai is also that land use planning has been conducted in a context in which public does not perceive the need for or benefit of it. Land appears to be plentifully available.

> *"Land use planning and its implementation are successful in areas where there has been serious land conflicts or in areas where the land is scarce. In Angai this is not the case. Land use planning should be demand driven."*
> *– National Level Actor –*

Not only in Angai but also in LUP nationally, donors play a strong role. Land use planning is not considered to be part of the normal duties and responsibilities of a district but as an extra-curricula activity funded by donors, coupled with generous allowances (see also NORAD 2012). During the PLUP process, theDistrict Land Use Planning team, Village Council, Village Land Use Planning Management Team and Village Natural Resource Committee receive allowances, and their participation is strong. It is not uncommon for daily allowances to be paid beforehand for the expected number of workday, while the actual number of working days is lower. In such a case, the additional per diem payments are not reconciled or returned. This practice is not regarded as wrong or stealing (see also ibid.). Furthermore, the experience gained during this PLUP process revealed that it is difficult to control such malpractices using existing democratic accountability mechanisms. An additional challenge is that activities primarily funded by donors, such as PLUP, have become more expensive relative to other public sector activities, consequently, e.g., land use planning is only done by donor funds (see also NORAD 2012; REPOA 2007).

The presence of donors also blurs the accountability structure. While the PLUP process is conducted by the district it is widely known that donors are funding the process. Nevertheless, a donor funded PLUP process represents an opportunity for the district achieve outcomes on matters for which they would not otherwise have resources. In principle, PLUP is the district's responsibility. Although LIMAS has been relatively invisible during the PLUP process, with a minimal presence in the villages and the DLUP team taking the lead, the presence of LIMAS is well acknowledged. While the district would like to take credit for conducting PLUP (recommended for all districts but financially challenging to execute), which would be justified, the presence of LIMAS will overshadow their contribution.

Discussion and Conclusions

The preliminary findings of this study, Responsive Governance in Climate Change Adaptation and Mitigation, a case study from Angai Forest, reveal that there are horizontal and vertical gaps in the responsiveness of governance. The former being that the official decision-making structures are open to all villagers but they do not recognize explicitly the importance of informal actors despite their influence being notable. And the latter being that, the international and national strategies do not conform to local realities although eco-social dependency has an impact at the local level violating the duty-bearers rights and blurring the national, regional and even municipal responsibilities and accountability measure. Studies similar to this one, and focusing on the local aspects of eco-social dependency are necessary as there is a tendency for international aspects and international institutions to dominate the discussion.

The impact of PLUP on the local governance structure in Angai is twofold: it has positively enhanced the implementation of laws, rules and guidelines emphasizing public participation but in reality donor funding has also hampered the genuine participation. PLUP is a concrete attempt to make governance more responsive, and to engage locals into village level decision-making, which is important for the sustainability of any actions relating to climate change adaptation and mitigation. Decision-making in PLUP relies on locally elected representatives (village council) and all of the villagers (village assembly), the rights and responsibilities allocated to them and the accountability measures that recognize the locally elected representatives, have all created equity and empowered citizens, and created an action space. In principle, the PLUP process is responsive, participatory, and inclusive. PLUP has strengthened not only the elected representatives but also villagers in general and it therefore promotes citizenship as a social practice. However, public participation and engagement in Angai is often ostensible. The reality at the grassroots level is complex (e.g,. illiteracy, donor presence) but national policies do not reflect this. For example, the strong donor presence makes meaningful citizen participation difficult if the primary incentive to participate is financial and therefore associated with a specific moment. Plans involving outside funding are easy to make, but unfortunately, the implementation and behavioral change do not follow. The motivation to participate should be broader merely the immediate benefit of doing so. Opting for immediate gratification is human, but to truly develop communities, individuals must to learn how to participate meaningfully.

True public engagement is necessary for the success of any climate change mitigation- and adaptation- related intervention. Angai communities suffer the consequences of decisions that have been made and therefore, it is their right to participate on such processes. According to this study, PLUP has positively affected the responsiveness of governance. The inclusive and participatory approach of PLUP also provides the potential to reduce the horizontal governance challenge. The governance structure currently in place in Tanzania does not recognize traditional leaders. Only elected local representatives (Village Council, Committees) are considered legitimate actors in the local governance processes. If openly and officially provided with an opportunity, traditional leaders might have the potential to support the efforts to domesticate and customize certain reforms (e.g. land use plans) according to local conditions. An inclusive approach to PLUP is an opportunity to bridge different local powers.

The research in Angai continues. In the following months the researcher will spend time in the field with an emphasis on participatory observation in the PLUP process to triangulate the findings and further deepen the analysis. The findings will also be compared with findings from other countries to determine whether Tanzanian experience is unique, and whether there is a possibility to share lessons learnt such that study could provide helpful material for intervention implementers.

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INSTITUTIONAL ANALYSIS AND ENERGY TRANSITIONS

Sustainable Energy in Rural Areas

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Access to energy is one of the most important factors in the development of modern civilization. It is estimated that in developed countries, daily electricity consumption attributable to the person is compared with the work of about 150 people. Furthermore, many modern processes can not be carried out without a stable access to energy. Rural development must also take into account the problems of energy supply. Today, it is important not only to ensure the sustainability of access to energy, but also its impact on the environment. For this reason the increasingly important role play concepts of sustainable and low-carbon energy. The purpose of this article is to present the theoretical aspects of providing energy in accordance with the principles of sustainable development. This means not only the use of appropriate technology, but a holistic systemic approach to these issues. It is worth mentioning, that sustainability must take into account not only environmental issues, but also social one, which means, being not only environmentally friendly, but also affordable.

Introduction and Background

Energy is one of the most important factors in the development of the modern world. From the historical point of view, this means replacing the work of human muscles with other sources. The main source of energy used by humans (excluding food) includes fossil fuels, which provide almost 87% of the demand (BP, 2013, p. 41). This consumption structure results in a number of environmental disadvantages caused by their extraction, transportation and combustion. As a result, the energy sector is a major emitter of greenhouse gases. Such a situation and forecasts of further growth in demand for energy (DECC, 2014; Exxon Mobil, 2014; IEA, 2013; OECD, 1999) make it necessary to change the approach to energy towards mainstreaming of environmental aspects of the sector. This means not only ensuring low emissions of harmful substances, but also a rational use of raw materials. In particular, this applies to crude oil, the resources of which – with the current level of consumption – are estimated to last only for 54 years (IEA, 2013, p. 72).

The best of the existing solutions seem to be to implement the concept of sustainable development. However, it is not so simple because there are differences in the interpretation of the concept of sustainable energy (Prandecki, 2014c). Typically, the controversy concerns the recognition of certain forms as sustainable (Prandecki, 2014a). Some believe that only renewable energy sources can be considered as sustainable, while others allow the use of additional low-pollution sources, such as nuclear energy, gas, and even coal if used with the CCS technology. However, the issues pertaining to sustainable energy cover not only the dilemma of the use of a certain type of sources, but much more complex problems, including e.g. issues such as social aspects of the concept, i.e. taking into account the role of energy price in human life and the availability of transmission networks.

The goal of this paper is to present the most probable factors influencing the development of energy in the middle of XXI Century, with a particular focus on rural areas of the Northern and Central Europe, i.e. the areas that already have access to energy.

Material and Methods

The basic method used in the study was a critical analysis of the available literature on the studies of the future, sustainable development and energy. In this regard one can distinguish four groups of sources: 1) books and studies on changes in the future economic trends, and sustainable development - their selection was based on the author's previous work, 2) reports, and books on sustainable energy and future trends in this sector – their choice was made on the basis of past experience and analyzes carried out in this field, 3) studies of the EU's energy policy – the main source of information were the documents of the European Union, supplemented by the comments in journals, 4) information about energy challenges in rural areas are based on scientific journals database search (Oxford Journals Collection, Science Direct, Scopus, Agro, BazEkon).

The starting point for the assessment of factors affecting the use of sustainable energy in rural areas in the perspective of 2050 is the analysis of global changes that may occur during this period. Brief characteristics of these issues has been developed based on the literature and multiannual research, in which I participated, conducted by "Polska 2000 Plus" Forecast Committee of the Polish Academy of Science. The identified trends were used to build energy development scenarios until the mid- twenty-first century. For this purpose, mainly the descriptive method was used. A long time horizon, i.e. the perspective of almost forty years, makes that the presented energy development trends and their consequences are fairly general in nature. However, due to the speed of changes in the surrounding, only the basic megatrends can be taken into account in such a long period.

Forecasting phenomena in the long term requires many simplifications and rejection of the possibility of unlikely events (Lempert, Popper, & Bankes, 2003; Taleb, 2010). For this reason, it is assumed that by 2050 there will be no global, violent phenomena of a negative nature, such as a world war, eruption of a supervolcano, collision of Earth with a cosmic body of large size, etc. This does not mean that such phenomena with a lesser scale will not occur. They can even slow down many important processes, e.g. globalisation, but are not able to stop them.

In terms of the principles of the concept of sustainable development, among other things, studies was used (Dresner, 2002; Soderbaum, 2008; WCED, 1987). On the basis of them, aside from various issues, including the problem of strong and weak sustainability, were can define the overall picture of the concept. Much more controversy is raised by the issue of sustainable energy. In most cases, it is characterised similarly to the definition of sustainable development presented by the Brundtland Commission (e.g. Lemaire, 2010; Patterson, 2009; Tester et al., 2005). However, in most cases this slogan entails initiatives oriented towards the environmental aspects of sustainable development, but disregarding the social issues (Prandecki, 2014b). In extreme cases, this concept is synonymous with renewable energy sources, which is an oversimplification. In practice, it involves a number of additional solutions arising not only from its production, but also from the distribution, including the mainstreaming of the role of markets and prices. In this study sustainable energy is understood as a combination of equitable availability of energy and preservation of the environment. It means that actions aimed at reduction of environmental costs of energy consumption should be taken in a way which limits availability of energy for societies.

Results

Global trends in social, economic and political conditions in 2050 are of major importance for the assessment of the evolution of the energy sector. The best starting point is to assess the demographic processes (Karpiński, 2007). According to the United Nations data (2013), it is estimated that by mid-century, there will be over 9.5 billion people on Earth, which means an increase of over 2 billion in comparison with 2010. However, the growth will not be uniform. In Europe it is even estimated that the population will decline from 740 million in 2010 to 709 million in 2050. Changes in population will be accompanied by additional processes, including urbanisation and population aging (Kleiber et al., 2011).

In rural areas of Northern and Central Europe development trends will be similar to the rest of the continent, but some phenomena will have a deeper character. In this regard, it should be emphasized the problem of an aging population and emigration of young people. The second of these phenomena is due to the different conditions of life. The most important factor is: the inconvenience of agricultural labor (e.g. difficult conditions, unpleasant working hours, dependence on weather conditions, mostly manual labour), combined with much lower revenue and difficult access to many cultural attractions cause the escape of young people from rural areas to cities. The result of these two factors will be much greater decline in the population compared to urban centers. Therefore, it is expected that progress in the mechanisation of agriculture will continue and the average area of farms will increase, which entails an increase in demand for energy.

Economic changes will also be of major importance. Shift of economic centres towards Eastern Asia has already been noticeable for a long time (Kukliński et al., 2012; PwC, 2013; Randers, 2012; Ward, 2012). This process will be continued (Prandecki et al., 2013). With the increase of wealth, the growth rate in developing countries will decrease, but by the middle of the 21st century, it is expected that the average standard of living will be comparable with the countries of Central Europe (OECD, 2012). This means the need to meet consumer needs of a substantial part of humanity, which has been deprived of the opportunity to take advantage of the benefits of civilisation (Kołodko, 2013). This process is very likely to be much stronger than the stabilisation of consumption in developed countries, which means that the level of global consumption should not only continue to rise, but also be far from the patterns of sustainable development (Prandecki et al., 2013). In combination with the high population growth rate, this means a rapid increase in the demand for energy. In consequence, energy prices will rise, which will also impact the European energy sector.

Changes in the primary energy demand will be also affected by the technological progress (Toffler, 1984). The strength of impact of this factor is difficult to determine, but the new trends will certainly lead to an increase in the consumption of energy, in particular electricity, in daily life and in industrial production. Contribution to it will be made by the progressing automation and the information revolution providing opportunities for mobile communication (Naisbitt, 1984; Toffler, 1984). For this reason, further increase in the demand for energy is expected, but its volume is difficult to estimate because the technological progress itself increases energy efficiency, and thus reduces the consumption of energy to achieve a given objective. Changes in technology will also lead to the use of new energy technologies (e.g. hydrogen and methane hydrates) and to the increase in the efficiency of energy conversion, which may also lead to changes in the demand for energy resources.

Additionally, geopolitical determinants should be pointed out. Most of the significant resources of crude oil and natural gas are located within the areas that are politically unstable, which causes the risk of interruption of the supply of raw materials (NIC, 2008). An exception is shale gas that comes from the United States, but its mass export does not have to be permanent, but merely a tool of intervention and assistance in emergency. The risk of interruption of supplies applies in particular to Europe, which is characterised by a high level of dependence on imports of primary energy, which for several years has remained at a similar level, i.e. nearly 54% in 2011 (Eurostat, 2013, p. 30). It is anticipated that, contrary to EU initiatives for the development of renewable energy sources, the level of dependence will continue to remain at a high level. It is estimated that by 2030 it will rise even to 70% (WEC, 2008). After this period, stabilisation may occur or even a decrease (depending on the level of reforms), but the ratio will still remain at a high level.

The factor that causes the changes in the energy sector is a growing environmental awareness of the societies. Uncontrolled technological progress leads to over-exploitation of natural resources, climate change, loss of biodiversity, and excessive emissions of waste (including hazardous waste) into the environment (Komiyama, 2014; Meadows et al., 1972; Meadows et al., 2004). With the growth of population and the progress of civilisation, environmental problems become global, which results in the necessity for global initiatives in this regard. Due to the large scale impact of the energy sector on the environment, in particular in the area of greenhouse gas emissions, it is one of the core areas of implementation of the environmental policy. As a result, there is a strong trend towards greening of the energy sector, which consists mainly in promoting renewable energy sources (RES), efficient use of the existing resources and reducing greenhouse gas emissions (IEA, 2013; Skea et al., 2011). Such a policy, called the climate and energy policy, is particularly evident in the European Union, but it should be emphasised that this is a global trend noticeable among others in the policy of China (NPC & NDRC, 2011).

Given the above factors, it can be assumed that the energy problem in the middle of the 21st century will be much more complex (O'Keefe et al., 2010). This is due to the need to consider much greater than today amount of factors that have impact on the sector. Moreover, a rise in the number of entities active on the market is predicted. This applies mainly to small installations using RES. One should expect a further increase in demand for primary energy, but its scale is difficult to estimate (BP, 2013; Exxon Mobil, 2014; Shell, 2011; WEC, 2013). Depending on the taken initiatives, e.g. energy efficiency ones, it is estimated that by mid-century, the increase in consumption might range from 27% to 61% (WEC, 2013), where for electricity it will be much higher. Exxon assumes that electricity demand in 2040 will increase by 90% (Exxon Mobil, 2014). On the basis of these documents, one can define five basic trends related to the energy, i.e. increase of demand, efficiency of consumption and production, electrification, greening and location (decrease of distance between producer and final consumer).

In the European Union, the energy problem has been a priority for several years. However strategies do not contain distinction between problems of rural and urban areas, but have a significant impact on their performance. For this reason, general characteristics is necessary. In the 2050 perspective, it was assumed that it will be necessary to shape it so as to limit the temperature rise to plus two degrees Celsius in order to reduce the effects of climate change (EC, 2007). In addition, it is assumed that the development of this sector should be consistent with the objectives of sustainable development (EC, 2006), but in practice the strategies in this area should be seen as more pro-environment rather than sustainable. Mostly EU energy policy refers only to two basic aspects: climate change in terms of reduction of greenhouse gases and security of primary energy supplies. On the other hand lack of interest in the social aspects of energy sustainability as well as ignoring problems of production and consumption of energy in industry are noticable. The result of such a situation is to focus on energy conversion technologies (with an emphasis on renewable energy and gas), and the omission of the problems of its transmission and use. There is no reliable discussion on the economic consequences of new solutions. Particularly problematic is the growing competition from outside the EU, which is not limited by any standards. There are economic instruments that could alleviate inequality, but it is not willing to use them. The result is problems with unemployment. Furthermore the social consequences of change, especially in the less developed member states are only minimally considered. In these countries, the changes lead to an increase in energy prices and the consuming devices. It can lead to the exclusion of access to energy. Policy implemented without social needs can not be called sustainable (Prandecki, 2014b).

One exception is the proposal for period 2020–2030 (EC, 2014). It includes some of economic and social aspects of energy production and consumption, but it is still difficult to treat such an approach as sustainable.

By 2050, the European Union intends to shift its economy to a low-carbon one (EC, 2011a). The consequence of this step is the need for a radical restructuring of the energy sector in order to simultaneously ensure the security of energy supply and reduce greenhouse gas emissions by approximately 80–95% (EC, 2011b). This goal is to be achieved mainly by increasing the use of RES. However, it will be gradual, which means right now the need to develop an appropriate energy mix that incorporates different types of sources (EC, 2013). When analysing the future energy mix structure, the problem of the slow pace of changes in the sector should be pointed out. It results from the high costs and long payback period, and thus the slow rate of replacement of technology. In consequence, numerous energy conversion plant currently under construction will continue to operate in 2050. It is estimated that since the introduction of a new solution in order for it reach 1% share in the global market, approximately 35 years have passed (Voser, 2009). With the accelerated pace of transformations in the economy, this period will be reduced, but it will still be longer than in most other areas of economic activity.

Energy efficiency is also taken into consideration as one of the basic steps to implement the new policy. However, the complexity of the issue makes it difficult to implement effective solutions. It is demonstrated by another amendment to the Directive on energy efficiency and the delay in submitting a proposal for actions in the framework of the strategy for 2020–2030 (EC, 2014).

Development of sustainable energy systems means not only the issues related to energy sources and the efficiency of its use, but also concerning the stability of the whole system and provision of consumers with access to this good. The latter matter should be understood not only in the aspects of physical availability, but most of all social conditions, i.e. such a level of energy prices (regardless of the form, for example in the form of fuels, electricity or heat) that does not result in social exclusion. This means that, on the one hand, it is necessary to form the prices so that they fully include these externalities and, on the other hand, do not create a barrier to access for poorer people. Various forms of energy, in particular electricity and heat, should be one of the basic commonly available goods. On the other hand, assurance of low energy prices causes a decrease in the effectiveness of energy efficiency because its sufficiently high level is the most effective incentive to save. As a result, from the civilisation point of view, the use of market mechanisms in the distribution of energy should be corrected in terms of ensuring access for the poorest because the exclusion in this respect will cause a permanent inability to return to the path of development.

Sustainable energy within rural areas is understood in the same manner as in urban one. This means a long term delivery and consumption of energy, which is environmentally friendly, universally accessible and profitable (in terms of production). Above mentioned trends, i.e. increase of demand, efficiency of consumption and production, electrification, greening and location (decrease of distance between producer and final consumer) are more or less the same. Only the scale is different. This is due to the (comparing with urban areas): smaller number of consumers, smaller demand (less energy consuming industry and infrastructure, e.g. public transport, street lights), greater dispersion of them, generally weaker distribution network and lesser purchasing power of inhabitants. This results in the need for different treatment of the energy problems in rural and urban areas. In terms of thermal energy such differentiation already takes place, i.e. the countryside is dominated by diffuse sources that are rarely used in European cities. In this regard, we should not expect major changes. The concentration of heat production in the densely built-up villages and relatively high population is possible, but the scale is not comparable to the city. Sustainability of heat energy means mainly changing the methods of production to more environmentally friendly one and increase the efficiency of its consumption. In the second aspect, the possibilities of achieving the benefits are significant. However, the creation of appropriate policy is very difficult. Unsuccessful attempts at EU level are the most striking example. It is reasonable to carry out appropriate education to increase awareness of the costs and benefits of energy efficiency. It is also worth noting, that emissions from small scale installations are not included in EU Emissions Trading System. In the future it will probably change. This may be the biggest agent of modernisation.

Electricity problem is more complex. On one hand, the differences between urban and rural areas necessitate a different design of the system, on the other, their separation would be ineffective. Long term EU energy policy put stress on RES usage. Usually they are located in rural areas and produced in this way energy is consumed in cities. Growing demand makes it necessary to increase production capacity and improve network security. In the European countries, most transmission lines were built a long time ago. By mid-century this causes the need for their modernization. The situation in this field is worse in rural areas than in urban one. Differences in demand and population density make it necessary to adapt the capacity to the needs of society.

In order to avoid transmission losses, the distance between producer and consumer of energy should be minimized. For this reason, in rural areas, it is better to use a minor installations. In most cases, they may be renewable, but it should be kept in mind that, for example, wind turbines and photovoltaic panels involve the risk of power outages. The way to solve this kind of problems should be the solutions for mass storage of energy. Today, this problem is unresolved, but works on it are underway in a number of research centres. It gives hope that in the long-term perspective, i.e. until mid-century, such solutions will be used. Most likely, however, it will be necessary to supplement solar and wind power by more flexible solutions, e.g. traditional non-renewable sources, or installations based on the combustion of bioenergy (biofuels, biogas and biomass). It is necessary because of regular daily (and annual as well) changes in energy demand. The system must be prepared for biggest consumption, which means the necessity to switch off some power plants during most of the time.

Usually, it is believed that an important role in agriculture should be played by bioenergy, in particular by biomass and biogas. However, such an approach should be used carefully so that investments are profitable, i.e. the size of the installation has to be suitable for the production capacity of the region and large enough to provide a return on investment. This means that the technology should be used only in appropriate scale. In particular, this applies to bioenergy. Numerous examples show that too large installation leads to the necessity of obtaining resources from long distances, which ceases to be profitable. The result is an increase in energy prices.

It is worth remembering that the creation of sustainable energy plan for rural areas needs holistic approach, based on availability of resources, their environmental pressure, costs and social needs. Moreover sustainable system should be flexible. It means creation of a proper energy mix instead of excessive use of a single relatively cheap technology (eg. wind energy). The problem is not only the risk of interruptions in energy supply, but also its oversupply. A large number of small sources of energy is more secure than a single large installation, as in the case of failure one or more sources or lines, distributed network can still operate. In rural areas that are more exposed to the risk of failure, it might be important.

In the literature one can find a lot of discussion on the technical aspects of the application of various technologies. Analysis of the economic costs and benefits are also available. Rarely mentioned are the issues of social aspects of the anticipated changes. The trend towards sustainability in the energy sector should result in the improvement of environmental quality. This is particularly important in the reduction of greenhouse gases and particulate matter into the atmosphere (the problem is practically solved in most European countries). Moreover, the use of more efficient and renewable sources will help to reduce the use of non-renewable one. On the other hand RES cause other types of environmental impacts, e.g. noise, changes in the landscape, breach of the functioning of ecosystems.

In addition, local conditions should be taken into account. Construction of the power plant on the river which is the main mode of transport, will not meet with favor of residents. A similar effect will trigger a wind farm built in areas attractive because of the beauty of the landscape.

Social dimension is an important aspect of a sustainable energy system. Safe and environmentally friendly system must be accepted by society. This means the tendency of inhabitants to use, acceptance of negative effects (regardless of the technology they are always there), and the acceptance of the costs associated with its construction and operation. There is no one rule for establishing the relationship between these factors. For this reason, each case of local power grid construction should be analyzed separately.

Discussion and Conclusions

Energy use in 2050 will be even more important than it is today. Such problems will be more complex due to the increasing competition between countries, resulting in an increased speculative pressure on world prices of primary energy. In part, these processes can be mitigated through the implementation of new technologies (mainly in the field of energy efficiency and energy storage), but it is still anticipated that the consumption of energy, in particular electricity, will significantly increase. For this reason, the use of alternative raw materials, e.g. methane hydrates, will continue to be an important trend in the development of the energy sector.

In Europe, where access to energy is not a major problem, the challenge is the need to modernise aging facilities and networks. In the perspective of over 35 years, it can be assumed that approximately 80–90% of the devices will require replacement. In particular, the more and more complex EU policy and the need to meet stringent requirements will contribute to it.

Rural areas also will be subject to changes. Usually, their pace is slower than in large population centres, but due to the increase in the global demand for food and unfavourable demographic situation in Europe, it should be expected that the mechanisation of agriculture will continue to grow and thus the demand for energy will increase as well.

The specifics of rural areas, such as open spaces and access to renewable energy sources in the form of biomass, mean that the residents of these areas may become an important user of small installations, mainly in the field of RES, which will contribute to the reduction of emissions of harmful substances into the environment. This way, rural areas can make a significant contribution to the development of prosumer energy. In addition, the widespread use of small installations improves the market because it leads to a reduction in the importance of an oligopoly of large corporations and increases safety by reducing the consequences of the shutdown of one or several plants.

The development of prosumer energy of rural areas, however, is dependent on the relevant economic policy of the state, which not only will not be worried about the operation of a distributed market, but will even emphasise the use of the technologies that enable secure processing of small amounts of energy and the combination of installations into local networks that make it possible to provide a sustainable energy supply for every recipient. Such a network should be adjusted to local needs and adequately diversified. The role of the state should not be associated with the use of specific subsidies associated with the construction of infrastructure, but more with the creation of institutional arrangements aimed at removing barriers to market entry.

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A Framework for Overall Sustainability Assessment of Local Small-Scale Energy Production – Demonstration of an Approach

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Climate change is one of the most difficult challenges facing the humankind during this century. According to the latest IPCC report, stabilization of the atmospheric CO_2 concentration on acceptable levels implies deep cuts in anthropogenic greenhouse gas emissions. In order to achieve this, drastic changes in energy supply and use systems are required. New energy production systems need to be designed so that they match these requirements. Sustainable local, small-scale energy systems based on renewable energy sources are one way of addressing this challenge. However, also renewable energy could cause negative environmental or other sustainability impacts, such as eutrophication or emissions of toxic substances. Therefore, comprehensive tools are needed to ensure that the sustainability of the systems is actually materialised.

The purpose of this study is to develop an assessment framework for analysing the overall sustainability (i.e. environmental, economic and social sustainability) of local, distributed energy systems. The assessment framework provides a tool for policy- and other decision-makers to assess the sustainability of different local energy production solutions. It covers all the aspects of the decision-making process ranging from energy availability to the actual measuring of the sustainability impacts. Application of the framework will be demonstrated through case studies.

Introduction and Background

Climate change is one of the main challenges the human kind will be facing during the next decades. The latest IPCC report predicts that without additional emission reduction efforts, global greenhouse gas emissions will double by 2050 (Edenhofer et al. 2014). In order to limit warming to two degrees, global greenhouse gas emission should be reduced by 40–70% by 2050, and cut down close to zero by 2100. Even larger reductions will be required in the industrialised countries.

Local energy production or decentralised energy production refers to relatively small scale energy production operating independently or connected to a distribution network. Main energy source is usually renewable but sometimes also fossil fuels can be used, particularly in combined heat and power (CHP) production (Altmann et al. 2010).

Most of the global greenhouse gas emissions originate from energy production. In order to drastically cut down emissions and decarbonise the energy production system, new innovative solutions are needed for energy production. Increased use of renewables is likely to involve a move from the present centralised energy system to more decentralised energy systems. Thus, local energy production solutions are one promising option for reducing greenhouse gas emissions. Indeed, decentralised energy production has been identified by many as a potential way of reducing emissions, both in Finland and abroad (e.g. Airaksinen et al.; Altman et al. 2010, Singh & Parida 2010). In addition to reduced greenhouse gas emissions, the transition to more decentralised energy systems is also driven by concern over energy security (Chmutina & Goodier 2014).

Finland is the most northern country in the European continent with sparse population and long distances. Due to the cold climate, heating requires a lot of energy. Its share of the final energy use was 25% in 2013 (Official Statistics of Finland, 2014). Energy production in Finland is mainly based on oil, wood fuels and nuclear energy (Figure 1). Share of district heating is large, its production was about 34 TWh in 2011, which represented about 28% of the total energy consumption of housing (Energiateollisuus 2012 & Statistics Finland 2012).

According to the EU 2020 energy and climate policy package, Finland needs to increase the share of renewable energy to 38% of the final energy use by 2020. Moreover, Finland aims to increase the share of liquid renewable fuels to 20% by 2020. The national targets for renewable energy use in 2020 have been specified in the National Renewable Energy Action Plan (NREAP, Ministry of Employment and Economy 2010).

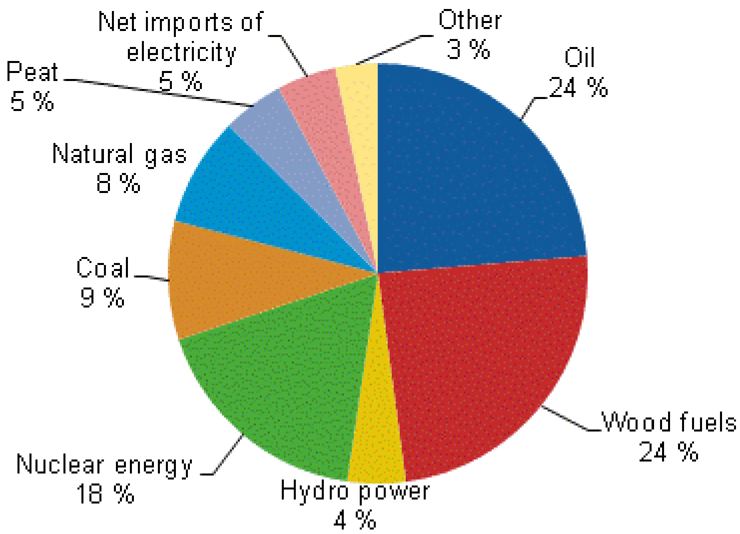

Figure 1. Total energy consumption in Finland in 2012 (Official Statistics of Finland 2012).

Aim of the study

There are no uniform criteria for sustainability assessment of local (municipal, regional) energy systems and for urban planning. Many municipalities and regions have set targets or programs for sustainable development (eco-cities, eco-villages etc.) but thus far no verified and uniform criteria for the development of sustainability at system level exist. Monitoring of the programs for sustainable developments is also not yet a common practice (Neves & Leal 2010).

In order to comprehensively assess the sustainability of regional energy system, many studies have introduced approaches that can be applied in regional energy planning (e.g. Mourmouris & Potolias 2013, Domac et al. 2011, Terrados et al. 2009). For example, Terrados et al. (2007) applied SWOT analysis in the design of the energy system in the Jaén province in Spain. In another study conducted in Germany, regional biomass-based energy production paths were analysed through three criteria, i.e. agricultural profitability, greenhouse gas efficiency and environmental sustainability (Hagen 2012). Hacatoglu et al. (2013) present a set of 22 indicators, which can be used to assess the environmental, economic and social sustainability of community energy systems.

The purpose of this study is present a general assessment framework, which can be used to analyse the overall sustainability (i.e. environmental, economic and social sustainability) of local, decentralised energy production systems. The framework consists of a set of questions that should be taken into account when developing a local energy production system. It does not aim to be a comprehensive frame covering all possible aspects but rather provides a tool for policy- and other decision-makers to assess the sustainability of different local energy production solutions. Moreover, contrary to e.g. the framework presented by Hacatoglu et al. (2013), the framework of this paper does not define the goals of this assessment. Instead it provides guiding questions that should be taken into account when conducting the assessment but leaves the goal definition to the decision-maker applying the framework. Application of the framework will be demonstrated through three different case studies: local bioethanol production from agricultural raw materials, combined heat and power production from forest residues and a net zero-energy housing system.

Material and Methods

A framework covering relevant questions related to the assessment of environmental, social and economic aspects of local, distributed energy systems was developed (Figure 2). The framework was applied to assess three different case studies: district heat production based on forest bioenergy, bioethanol production from crops, and a net zero-energy house. The framework development was implemented as a co-operation between researchers from three research institutes (MTT Agrifood Research Finland, Lappeenranta University of Technology and VTT Technical Research Centre of Finland). Researchers from each of these three research units with expertise in sustainability assessment of biofuels, agro-biomasses and energy systems drafted the skeleton of the model/approach for selecting sustainable energy production options. After drafting, the applicability of this framework was tested on the case studies. While the approach was tested, it was also further reiterated to better serve the decision making process. The framework can be used by different decision makers, e.g. municipal authorities, energy companies or consultants, in different stages of the decision-making process.

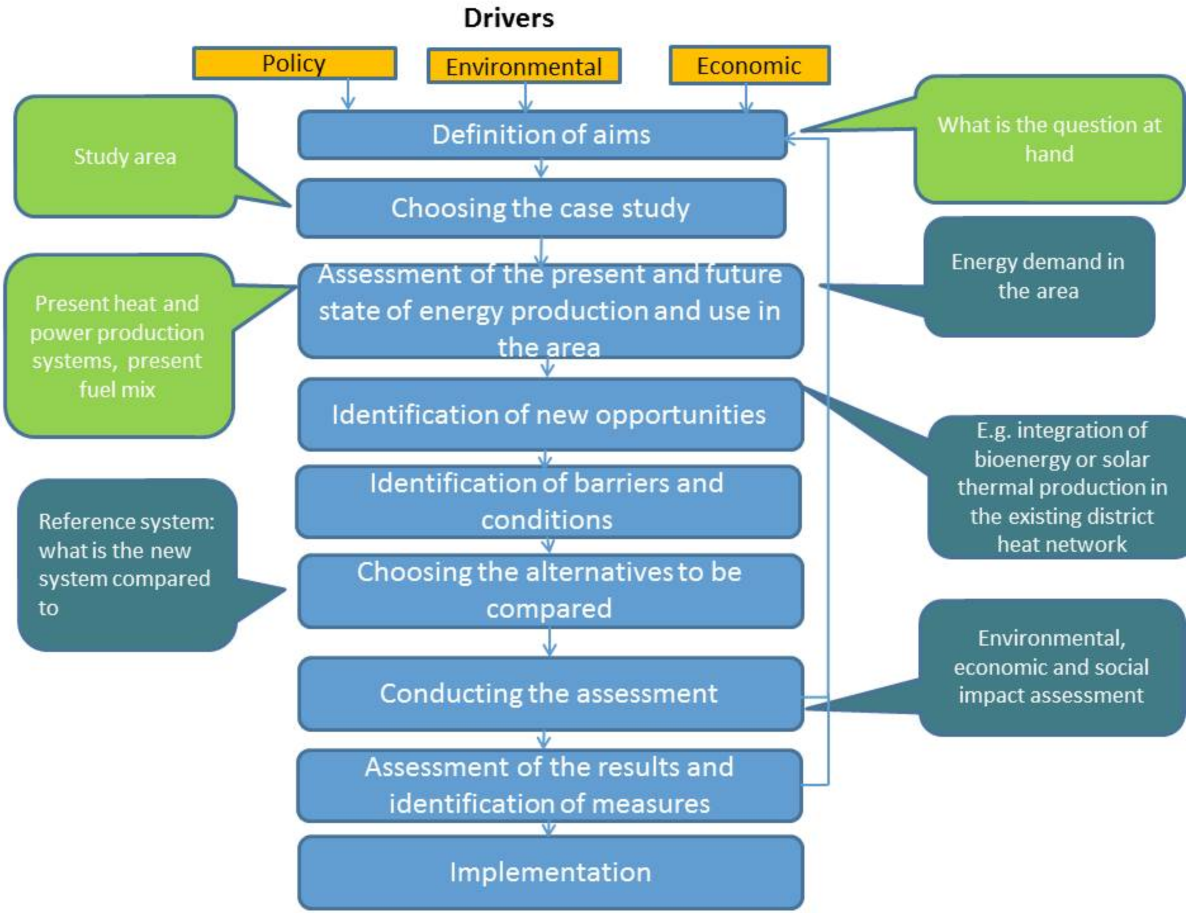

Figure 2. Framework for assessing the sustainability of local energy production system. Different drivers impact the use of renewable energy. These drivers are often interrelated (see e.g. Chmutina et al. 2014).

Description of the case studies

Net zero-energy house

The net zero-energy house assessed in this study is a one family house situated in the Hyvinkää town in Southern Finland. Energy production of the house is based on solar power and ground-source heat pumps. During the summer months the house produces more electricity than it uses, while in winter it needs to purchase electricity from the national grid. The excess electricity produced in the summer is sold to the national grid and the house is therefore defined as net zero-energy house.

The estimated total annual electricity consumption of the house is about 8460 kWh, of which 4510 kWh is consumed by household appliances, 2320 kWh by heating and 1630 kWh by heating of water (Energiatehokas koti 2013). There are 60 m² solar panels and 6 m² solar collectors, which reduce the annual net electricity consumption of the house to about zero.

Small-scale bio CHP plant

The small scale bio CHP plant case study is situated in Taipalsaari. It is used alongside an old heating plant in Saimaanharju. The plant produces 100 kW electricity and 300 kW heat (annually even 800 MWh electricity and 2 500 MWh heat). So far energy production of the plant is based on wood pellets but it will eventually be changed to wood chips. Electricity production is based on a micro turbine that runs on pressurized air. The aim of using pressurized air is to have as reliable and error free operation as possible. After the testing period, the facility should run mainly on remote control and staff will only be needed on site when fuel is supplied to the plant and during weekly inspections. (Ekogen 2012) The produced heat is directed to district heating network and replaces heat produced by natural gas (Karhunen & Koskelainen 2013).

Bioethanol

Bioethanol plant under this study does not yet exist. According to the plan, the plant would produce circa 100.000 tonnes of ethanol per year from grain. Part of the grain raw material is rotten, i.e. it would not be not suitable for food or feed use. Procurement area for grain would be Southwest Finland where the cultivation area is sufficient to meet this demand. Bioethanol plant would be combined with biogas plant, which produces heat and electricity needed in the ethanol production. The biogas plant would use distiller`s grain from ethanol production as a raw material. Distiller`s grain could also be used as animal feed, but it would not be economically profitable to transport it long distances due to its high water content. The excess electricity from biogas CHP would be sold to the national grid.

Results

In this study the assessment framework was applied qualitatively on the selected case studies. It mainly provides a list of issues that should be taken into account. Further assessment can be conducted quantitatively by applying suitable methods, such as LCA, social LCA and cost-benefit analysis.

Table 1. Assessment of the case studies using the framework

	Small-scale CHP	Bioethanol production	Net zero-energy house
Present and future state of energy production and use in the area	Currently the households connected to the district heating network are warmed with heat plant that uses natural gas as a fuel. Annual heat consumption of the area is 7000 MWh/a.	There is still need to produce more liquid transportation biofuels in Finland than current production capacity.	There is a wide variety of energy sources used in the houses in the area. Some are connected to district heating network, in some houses part of the electricity is produced with solar energy and some are so-called passive houses.
Identification of new opportunities	Existing infrastructure with district heating network enables the cost-effective utilization of small scale CHP production. Old natural gas boilers would need to be renewed if natural gas was utilized for heating also in the future.	There are different possible raw materials (grain, straw, waste) and technologies (1st or 2nd generation) to produce biofuels.	Heating requires about 25% of the total final energy use in Finland, and is responsible for a large share of emissions as well. Thus there is a lot of potential for energy demand and CO2 emissions reduction in the sector.
Identification of barriers and conditions	Availability of combustible biomass from nearby areas. For cost-effective production, the plant needs to be scaled to constant consumption and part of the energy still has to be produced using existing natural gas heat plant during peak load times.	Availability and price of raw materials in appropriate procurement area. Availability and price of technology. Also legislation, e.g. sustainability aspects in Renewable Energy Directive (2009/28/EC).	Timing of energy production not always matches the demand. Electricity needs to be purchased from the grid during winter months.
Choosing the alternatives to be compared	1. Small scale CHP production 2. Renewal of existing natural gas boilers	Choosing the technologies and raw materials that fulfil the above-mentioned conditions: Raw material: triticale, barley or wheat. Technology: process energy from biogas CHP which uses distiller`s grain as raw material, or distiller`s grain to feed and energy from wood chips	1. Net zero-energy house 2. House built with the 2012 standards and connected to district heating 3. House with same building materials as 1 but electric heating from the grid instead of solar power
Assessment methods	Environmental impacts can be compared with e.g. LCA, economic impacts with e.g. LCC, cost-benefit analysis, and social impacts with e.g. social LCA.	Environmental impacts can be compared with e.g. LCA, economic impacts with e.g. LCC, cost-benefit analysis, and social impacts with e.g. social LCA.	Environmental impacts can be compared with e.g. LCA, economic impacts with e.g. LCC, cost-benefit analysis, social impacts with e.g. social LCA.
Assessment of results, identification of measures	Comparison of different alternatives, choosing the best alternative and identification what measures should be used to enable implementation.	Comparison of different alternatives, choosing the best alternative and identification what measures should be done that enables implementation.	Decision made on the basis of the assessment. Identification of possible measures needed to reduce impacts.
Implementation	Environmental impact assessment, environmental permit, planning permissions and other permissions needed	Environmental impact assessment, environmental permit, planning permissions and other permissions needed	Environmental impact assessment, environmental permit, planning permissions and other permissions needed

The case studies used as examples represent different sectors and also different energy production needs. Various aspects are emphasised in different cases. For instance, impacts on local employment and economy in general are central social impacts related to the CHP and bioethanol cases. Main environmental impacts are also likely to be local, particularly if fuel production areas are situated nearby. On the other hand, the impacts of an individual house are likely to be much lower for the local economy. In the case of the net zero-energy house, a significant part of both social and environmental impacts is related to the production of the materials used in building.

Discussion

Decentralised energy production can involve many benefits, including increased energy security, reduced greenhouse gas emissions and lower production costs (Chmutina et al. 2014). In rural areas, investments in bioenergy and other renewable energy sources may offer employment opportunities, enhance the efficient use of rural resources, improve energy security and bring about environmental benefits (Lehtonen & Okkonen 2013). According to Johnson and Altman (2014), rural regions can benefit economically from bioenergy because in a bioeconomy the costs of the central petro-economy are replaced by the benefits of space availability in the decentralised bioeconomy.

On the other hand, it has been increasingly recognised that systems relying on decentralised energy production set challenges for the total energy system due to increased peak electricity demand. Thyholt and Hestness (2008) found that low-energy building with electric heating had higher CO_2 emissions than a house connected to district heating despite having lower energy consumption. Many renewable energy sources require increased reserve capacity due to intermittent production (e.g. Altman et al. 2010). There may be problems related to increased bioenergy use as well. The climate impacts of biofuels have been debated a lot during the past years. It has been found that indirect land use impacts of biofuels or warming impacts related to long-rotation biomass may in some cases be high (Smith et al. 2014).

When assessing the sustainability of local energy systems, it is clear that local impacts are not the only aspects that should be considered but the system should rather be seen in a wider perspective, looking at the whole life cycle of the system (see e.g. Mattila et al. 2010, Sokka et al. 2011). As local impacts may only represent a fraction of the total impacts, methods covering the whole life cycle should be used.

There are also other assessment frameworks (e.g. Mourmoris & Potolias 2013; Domac et al. 2011; Terrados et al. 2009; 2007) but the framework presented in this study differs from those in that it aims to give a very general methodology that can be used by decision-makers without much prior knowledge on similar assessments. The thoroughness of the assessment depends on the aims of the study. Less or more indicators (environmental, economic and social) can be used in the study, depending on its goals. The framework helps the decision-maker to understand the kind of questions that need to be taken into account.

Conclusions

The assessment framework presented in this paper can be used to assess the sustainability of different local energy production systems. The framework has been developed for Finnish conditions but could be used in other countries as well. Its purpose is to help one to gain a comprehensive view of the different questions related to developing a new energy production system. However, as is obvious, it is in no way all-inclusive. It should also be emphasised that that different aspects emerge in different cases and the framework and the assessment itself needs to re-iterated while conducting it.

Local decentralised energy production solutions are one option in reducing greenhouse gas emissions, It is obvious that there is no single path to climate change mitigaton but that efficient mitigation is likely to consist of a collection of different solutions. In order to achieve drastic cuts in greenhouse gas emissions, several complementary measures will need to be used. Decentralised energy production is one of them, whose complete potential is yet to be achieved.

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Perspectives on System Transition towards Renewable Energy and Energy Efficiency in Housing

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A systemic change is needed in order to achieve a transition to a sustainable and carbon free society. This requires an understanding of drivers and barriers and the dynamics of the socio-technical system around energy production and consumption. In this paper we use the multi-level perspective and innovation system functions to analyse the emerging innovation system around energy-efficiency and use of renewable energy in new housing districts. Our results indicate a need for education and communication, changing attitudes, service business, public and private collaboration, policy integration and better management of the whole system.

Introduction and Background

EU targets for mitigating the climate change ask for radical change in energy system in Europe. Housing for instance in Finland is using fourth of the total energy consumption of the whole country (24%, Energy statistics 2012). Therefore it is important to focus especially on housing in energy efficiency and renewable energy production.

In order to achieve a transition towards a sustainable and carbon free society, a radical systemic change is needed (see e.g. Elzen et al., 2004; van den Bergh and Bruinsma, 2008; Grin et al., 2010). This means looking not only at technological change, but also the change in societal structure, values and behaviour (van den Bergh et al., 2011). However, creating this transformation is problematic due to, for instance the complexity of the socio-technical system and its interlinkages (Geels, 2002; Geels, 2011) and different perspectives on the direction of change (Stirling, 2009). Creating systemic change thus requires an understanding of key leverage points, drivers and barriers and the creation of shared vision for the direction of the system.

There are different approaches to analysing sustainability transitions, such as innovation systems (IS), multi-level perspective (MLP), complex systems and evolutionary systems (van den Bergh et al., 2011). In this paper we combine insights mainly from the first two approaches by analysing an emerging sectorial innovation system and reflecting its performance against the socio-technical change as illustrated by the multi-level perspective.

The multi-level perspective (Elzen et al., 2004; Geels, 2002; Geels, 2011) offers an overarching view of the dynamics leading to a structural change of a regime. It stresses that socio-technical systems change through interplay between landscape, regime and niche level processes. Socio-technical landscape refers to relatively stable, slow-changing factors such as cultural and normative values, long-term economic developments and societal trends. Socio-technical regime refers to the semi-coherent set of rules (e.g. agreements, directives, moral codes) carried by different actors (such as users, policymakers, scientists, and public authorities) and practices and action models based on these rules, and interaction between actors. Niches refer to initiatives and activities in special application areas or bounded geographical areas. Socio-technical transition occurs when there is pressure from the landscape, which opens a window for new solutions developed in the niches to enter the regime and thus change the system. However, this does not mean that all transitions are similar; different types of transition have been identified (Geels and Schot, 2007).

The MLP can be regarded as a sort of heuristic to guide the overall analysis of system transition (Geels, 2011). However, in order to go deeper into the dynamics of the system and analyse the system failures and points of policy intervention, an innovation system approach is useful (Jacobsson and Bergek, 2011; Hekkert et al., 2007). The innovation system approach studies the structure and interaction of "all societal subsystems, actors and institutions contributing in one way or the other, directly or indirectly, intentionally or not, to the emergence or production of innovation" (Hekkert et al., 2007, p. 414). Innovation systems have been considered from different perspectives: national (e.g. Lundvall, 1992), regional (e.g. Cooke et al., 1997), technological (e.g. Carlsson and Stankiewicz, 1991) and sectoral (e.g. Malerba, 2004). While our case study is about a sectoral innovation system, we utilise the functions of innovation system developed mainly in relation to the technological innovation system.

The initial considerations of innovation systems emphasised the structural features enabling innovation, but more recent approaches analyse the processes and dynamics of the innovation system by proposing to study different "functions" of innovation system (van den Bergh et al., 2011). Different lists of the functions have been proposed (Hekkert et al., 2007; Jacobsson and Bergek, 2004), although they are rather similar to a large extent. We chose to adopt the list provided by Hekkert et al. (2007), which lists 7 functions:

1. Entrepreneurial activities: Activities of existing and new companies related to experimentation
2. Knowledge development: Production of knowledge related to the emerging innovation system
3. Knowledge diffusion: Transfer of knowledge within the system
4. Guidance of the search: Processes directing the focus of experimentation
5. Market formation: Activities to support the creation of new markets
6. Resources mobilisation: Financing, labour and other resources available
7. Creation of legitimacy: Processes related to the acceptance and attitude towards the innovation

We chose this list of functions because it was easily operationalized, could be used as a heuristic tool and fit our context well, considering for example knowledge development and knowledge diffusion as separate functions.

Material and Methods

As an empirical case study, we focus on the building of new sustainable housing areas in Finland. This broad concept encompasses energy efficient buildings to lower the energy demand, renewable sourcing of energy, efficient use and recycling of raw materials, sustainable water cycle and sourcing of food, transportation with low emissions and congestion, smart use of information systems and socially inclusive culture. However, our focus is only on the first two: 1) buildings that are energy efficient to lower the energy demand and 2) renewable energy to fulfil the decreased energy demand (cf. Similä, 2009; Koljonen and Similä, 2012).

In addition we have done an empirical comparison between the passive house innovation systems in Austria, the Netherlands and Finland. The comparison is based on interviews and literature.

Our analysis can be divided into three parts. First, we structured the results from the interviews and literature review with the Multi-Level Perspective. This was done to get an overall picture of the current regime and the pressures from landscape and niche-level experimentation. Second, we made a comparison of the performance of the passive house innovation systems in Austria, the Netherlands and Finland together with our foreign colleges (see Kieft et al. 2014).

Thirdly we analysed the performance of the emerging innovation system of energy efficiency and renewable energy use by using the innovation system functions as a frame. This was done based on the interviews, workshops, survey and the seminar. The purpose was to further describe the barriers to and drivers of change, but also to explore the differences in opinions of the actors regarding the barriers and drivers.

Fourthly, we analysed the interconnections between the functions, paying special attention to the differences in emphasis used by the different actors. We grouped the actors into four groups: industry, including construction and energy companies as well as service and energy solution providers; research, including technology developers and researchers from universities and research institutes; societal actors, including representatives from municipalities and ministries; and customers, meaning the inhabitants and end-users of the solutions (see Figure 1).

Description of the empirical material

The empirical material consists of three case studies which are reflected against the overall regime of building sustainable housing districts. The overall regime is constructed based on interviews, survey, international comparison and a discussion seminar. Hence, the material of the research was gathered in a process with different parts and various stakeholders. All the contacted stakeholders are listed in the Figure 1.

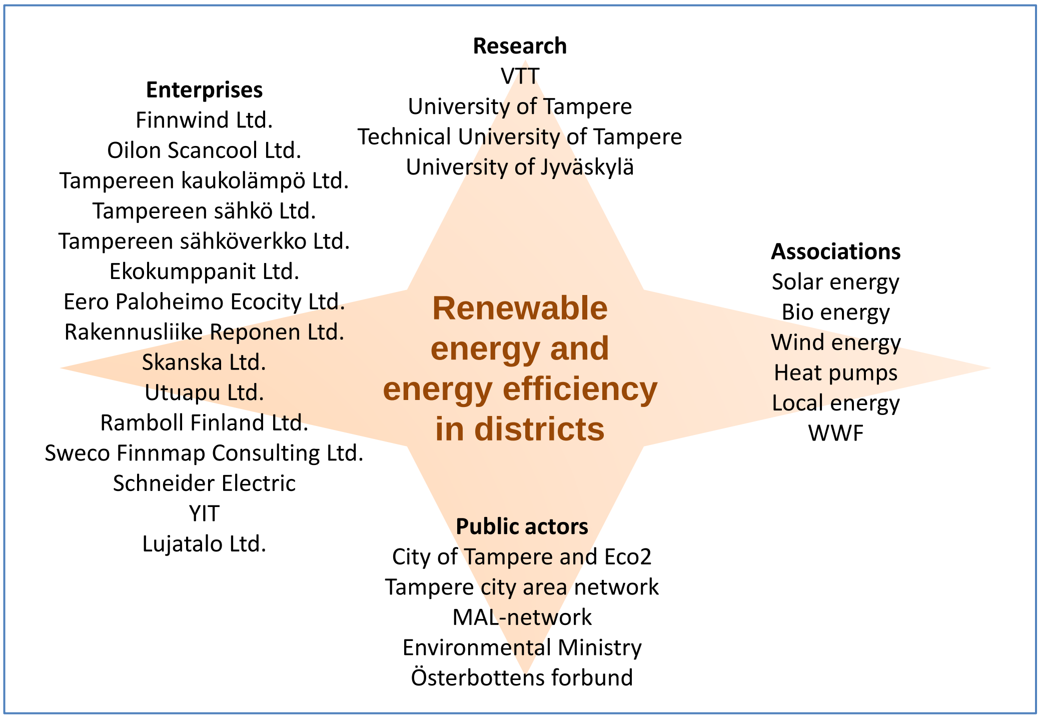

Figure 1. Stakeholders involved in the material gathering process of this research.

The three case studies focused on sustainability oriented new districts. The first one, Eco-Viikki is a historical case, the second, Vuores is in the building phase and the third, Härmälänranta is at the final design phase. Together the case studies provide both insights into the different phases of planning and building a new district, and to the changes that have happened in Finnish building sector from the end of the 1990s to the present.

The analysis of the first case, Eco-Viikki, is based on the material written during and after the planning and building process (see e.g. Väyrynen, 2010). Eco-Viikki was the first ecological housing area to be built in Finland. The planning started in spring 1995. It has been successful in testing many ecological solutions including solar energy, and creating ecological criteria for eco-efficient building as well as a model for collaborative urban planning. However, the effects on the dominant practices of the Finnish building sector remained limited (for further information, see Wessberg et al., 2013).

The second case study is a new housing district in Vuores area in Tampere called Isokuusi. The district will provide homes to circa 4 000 inhabitants, and the city's aim is to make the whole district carbon neutral. The building is about to begin and is planned to end in 2017. The analysis of the second case study was based on a participatory workshop facilitated by the authors. A full-day workshop for different city and energy related actors was arranged at 9th of April 2013 in Tampere in Finland. The workshop had two goals: 1) to list preferable energy options for Isokuusi in general and a part of Isokuusi called Harjanne in particular and 2) to identify carriers and barriers in implementing the identified energy options. The workshop produced suggestions for energy solutions to Isokuusi area and specifically to Harjanne as well as insights on the implementation, actors, carriers and barriers (for further information, see Wessberg et al., 2014).

The third case study is a planned housing area in Tampere called Härmälänranta. The area is former industrial area bought by the construction company. The new city plan has been created together with the construction company and the city. A vision has been to design an urban eco-efficient district, which respects the history of the area and at the same time provides attractive houses to citizens. The analysis of the third case-study was based on an interview of the planning architect of the construction company and a small workshop, where the representatives of the construction company (one person) and the city (3 persons) discussed the city planning process focused on Härmälänranta case and energy issues in it.

The selected case studies differ in timing and location, but also have many similarities, which make them comparable. All the three case-studies are located near a big city in the Finnish context. Eco-Viikki case is older than the other two cases and is located in the biggest and the capital city of Finland, Helsinki, which has 620 000 inhabitants (1,4 million in the greater metropolitan region). The other two cases are located in Tampere, which is the second biggest city in Finland with 220 000 inhabitants. The cases represent new housing areas located outside the city centre.

In this paper we have focused on describing the drivers and barriers on a national level. Therefore we have not compared the case studies. A comparison of case studies could bring more insights about the changes in both the temporal and spatial context. The Eco-Viikki was a pioneering case in Finland, and would offer a logical comparison point to the more recent cases. This comparison could also look at the effects of city size and location. We utilised the innovation system functions also in the analysis of the case studies, and therefore they could serve as a structure for the comparison. However, the comparison is outside the scope of this paper.

In addition to the case studies, we analysed the overall regime of sustainable building in Finland based on expert interviews and literature. In spring 2013 we interviewed 13 representatives of different actor groups in industry, research, and societal activities.

An international comparison was also made between the passive house innovation system of Austria, the Netherlands and Finland (further information in Kieft et al. 2014).

A customer survey on renewable energy and energy-efficiency in housing was conducted in spring 2014 to validate some of the initial results and gain a customer perspective. The survey was conducted via phone interviews of a representative selection of 1000 randomly selected consumers.

Lastly, a discussion seminar was held in March 21st 2014 where 36 participants representing industry, research and societal actors discussed energy issues in the context of city planning, based on the preliminary results from the interviews and workshops.

Results and discussion

Our focus on this paper is to analyse the drivers and barriers of an emerging innovation system by using the multi-level perspective and the innovation system functions. Therefore, we do not focus too much on the description of the overall context (for a macro-level perspective, see e.g. Similä, 2009; Koljonen and Similä, 2012). However, in order to get an understanding of the changes in the socio-technical system of the building sector with an emphasis on energy efficiency and use of renewable energy, we briefly describe the developments using the multi-level perspective (see figure 2). The landscape level pressures include for example international agreements, responses to climate change, digitalisation and the concept of smart cities. The regime level includes the development of legislation and research programmes as well as some dominating features of the Finnish building sector. For example, an interesting feature of the Finnish built environment is the use of district heating: about half of the buildings in Finland are connected to district heating systems, and in large cities the proportion is more than 90% (Similä, 2009). On the niche level, there have been and increasingly are local experiments in building sustainable districts.

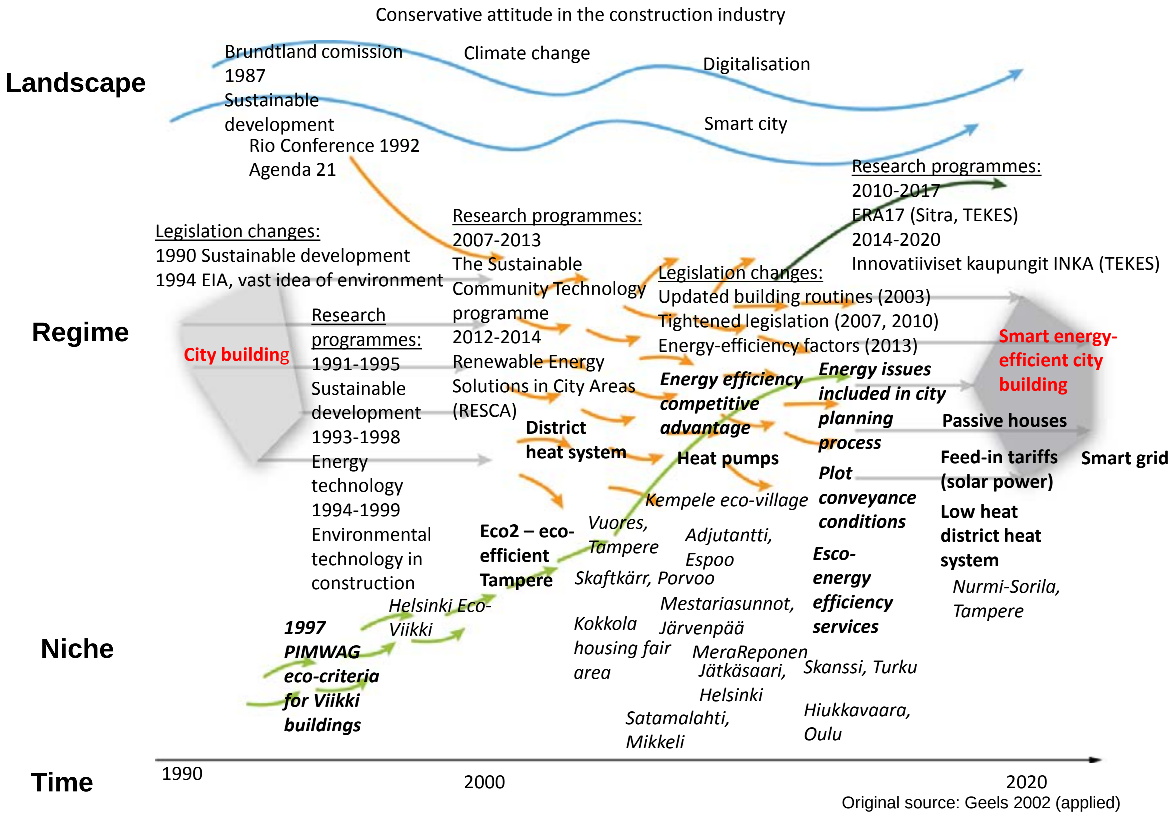

Figure 2. The context of the on-going change process in sustainable districts.

Analysis of the land comparison

In Finland houses are traditionally built rather energy efficient, because of the cold climate compared to other Europe. Insulation and windows are high quality as well as for instance the heat recovery systems are very common technical systems in Finnish houses. Still we must say that passive house market is an emerging market in Finland. However we can identify that the Austrian passive house markets are more developed: Austria has the highest density of passive houses worldwide (BMVIT 2009, see also Kieft et al. 2014). First passive house in Austria was built in 1996, and in the year 2000 there were almost 12.000 passive houses in Austria; Every 4th passive house worldwide is located in Austria (Statistics Austria 2013, BMVIT 2012).

There are several differences in country specific actions and policies as described in the Table 1. Based on this material it seems that the more local the decision making in building industry is the more success the passive house markets are. Also the integration of different policy sectors is favourable to passive house market formation, as well as financial subsidies. In Finland none of these measures has been strong.

Table 1. Differences in actions and policies related to passive house markets in Austria, the Netherlands and Finland.

	Austria	The Netherlands	Finland
Decision making	Decision making concerning construction industry is local and regional all nine provinces have their own housing subsidy schemes and building regulations	Centrally planned	Centrally planned (Environmental Ministry gives regulations) Cities have power in city planning processes and in giving conveyancing conditions for the plots.
Policy	Passive house technology is applied in social building projects: social policy, innovation policy and climate policy are integrated	Liberal policy dominates and has resulted to freedom of the markets and shortage of building land	Regulation leads the development
Subsidies	Subsidies are an important part of energy and climate policy. Subsidies are directed to building and renovation projects, not to people.	-	Minor subsidies to heat pumps and renovation. The Ministry of Employment and the Economy is providing energy subsidies to enterprises, cities and other organisations. Household deductions and other tax reliefs are possible in building projects.
Knowledge diffusion	Communication regarding passive house technology is actively intensified.	-	Knowledge diffusion is not working properly: e.g. lack of educations and education material

Analysis of the emerging innovation system by functions

The stakeholders described many barriers to the transitions towards increased energy efficiency and use of renewable energy in housing. We will next describe these by using the innovation system functions as a structure. A summary is given in table 1.

Table 1. The problems stated by the stakeholders.

Function	Barrier/ driver/ barrier+driver	Descriptions	Actor group who raised this problem
Entrepreneurial activities	Lock in to district heating	Pressure from the municipalities for new apartment building to join district heating	Industry
	Lock in to heat pumps	Lack of district level vision leads individual home owners to choose heat pumps as a readily available and easy option. Markets are opened up.	Industry, researchers
	Rapidly changing regulation	Industry cannot keep up with rapidly changing regulation	Researchers
Knowledge development	No knowledge available.	Not enough research and knowledge of energy efficiency in practice and possible challenges, for instance concerning the mould problems in passive houses. Knowledge gaps in the performance of existing practices, because of rapidly changing regulation guided by political pressure, not research finding	Industry, researchers, customers/ consumers
Knowledge diffusion	Insufficient diffusion of knowledge from research into practice	Problems in the diffusion of knowledge from research to practice. For instance a lack of education material and courses	Researchers, industry, societal actors
Guidance of the search	City plan too ambiguous Fear of favouritism	Too high risk in investing in district energy solutions because of a too flexible city plan. Preference to flexible city plan so as to not favour any single company	Industry, societal actors
	Role of consultants	Consultants have too much power over energy-efficiency regulation	Researchers
	Insufficient financial instruments	Financial instruments to guide the development of sustainable building are either lacking or insufficiently funded	Researchers, customers/ consumers
	Fragmented value-chain, lack of the overall picture of energy efficiency, lack of the owner of the process	The planning and building process is too fragmented and lacks an overall vision and cooperation between different actors. Cooperation is difficult. No overall view over the energy efficiency in the house level, district level and city level. The process of energy efficiency and renewable energy does not have an owner in the city.	Researchers, societal actors
Market formation	Lack of feed-in tariffs and practices	No compensation or guidance for feeding the energy produced in buildings to the grid.	Researchers
	Integration of different policy sectors	Market opening by integrating e.g. innovation policy, climate policy and energy policy	Researchers
	The power of consumers	Consumers have power in decision making and in investing on renewable energy and energy efficiency.	Industry
Resources mobilisation	Lack of service providers, lack of service business	There is a lack of skilled labour to maintain and service the new energy solutions	Researchers, societal actors
Creation of legitimacy	Lack of trust in new solutions Resistance to change	Conservative attitude prevents the experimentation with new solutions. The building sector is conservative and risk-averse, making change slow.	Industry, researchers, customers
	Financial values dominate the decision making	Customers are not willing to pay extra for energy efficiency or renewable energy, although they concider it important.	Industry, researchers, customers

Entrepreneurial activities

According to the interviews, there are two technological lock-ins preventing experimentation with new energy solution: lock-in to district heating and lock-in to heat pumps. The first lock-in was raised by the owner of a construction company, who argued that since plots are usually rented from the city, municipalities have vested interests in the use of district heating from municipality-owned combined heat and power (CHP) plants. According to the interviewee, while municipalities cannot force construction companies to join new apartment buildings to the district heating network, an "uncooperative" company may find itself having difficulty in acquiring rented plots from the municipality in the future. While district heating in itself can be a sustainable solution (Similä, 2009), the interviewee stated that the dominance of district heating in apartment buildings creates a barrier for the experimentation with other energy solutions. As the energy need for space heating decreases due to improved energy efficiency of buildings, also other options could be more feasible than existing district heating system.

In areas where district heating is not available, heat pumps have become extremely popular; research and societal actors interviewed described them as mainstream solutions. The stated reasons for this are a lack of coordination in the district level and the mature markets of heat pumps. Heat pumps are available and easy to install and use for individual home owners, whereas other solutions, such as bioenergy, wind and solar power are either not easily available in the market or would require a district scale implementation to be feasible. The survey to the consumers showed that consumers are not willing to invest to the new energy technology that is not mature. The problems with district scale implementation are discussed more in "coordination". It is worth noting that according to some research results, heat pumps, especially older installations, do not necessarily reduce energy use compared to e.g. direct electric heating (see Savolainen et al., 2013).

One challenge that the interviewees from research and industry stated was the rapidly changing regulation. The main institutions and political actors pushing the innovation system forward are the EU energy and climate targets and directives, which the Finnish Ministry of the Environment implements on the national level for the building sector. The construction of new buildings in Finland is guided by binding regulations (e.g. energy-efficiency, insulation, HPAC) and non-binding guidelines given by the Ministry. The regulations regarding energy efficiency stayed the same for more than two decades (since 1986). In the 2000s the regulations have been changed rapidly[3]. The current energy-efficiency is set by the law on the energy certificate of buildings[4]. According to the researchers and industry interviewed, most of the building companies have trouble keeping up with these regulations, which are also seen to be constantly changing. As an example, one interviewee from industry said that there are about 20 different documents relating to the energy-efficiency regulation because of the different versions from the recent years.

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[3] In 2003 the legislation was updated to answer the current building routines and in 2007 and 2010 the regulations were tightened a little. In 2013 the insulation demands were changed to be more flexible and primary energy factors were implemented. See Suomen rakentamismääräyskokoelma C4 (2003), D3 (2007) and D3 (2010), and Finlex 487/2007, 50/2013 and 176/2013.

[4] Finlex 50/2013. The certificate takes into account the properties of the building as well as the primary energy source: Fossil fuel has a factor of 1, electricity 1.7, district heating 0.7 and renewable energy 0.5.

Knowledge development

Finland is a leader in energy R&D and has strong national and regional funding organisations and strong collaboration with the industry (IEA, 2007). The technological solutions for improved energy efficiency already exist (Similä, 2009). However, there seems to be a lack of tools for assessment, monitoring and comparison of energy efficient building solutions as well as lack of data on which to base market value estimations (Häkkinen and Belloni, 2011). Interviewees from research stated that this is because of rapidly changing regulation causes challenges to the research which cannot follow the policies and regulations proactively, and because the new regulation usually changes the market conditions. The best knowledge about the impacts of certain policies comes after the policy has already implemented. According to one interviewee from research, in the "good old" times research came first and new regulation of policies after the research and knowledge creation. He continued that nowadays the regulation is pushed by EU-level agreements and research has to adapt to policy rather than advising it.

One specific concern in the building sector is that improving energy-efficiency, i.e. making the houses better insulated, will result in humidity and mould problems. The interviewees expressed different opinions about the connections between better insulation and humidity problems. According to one interviewee from research, focusing only on energy efficiency will result in humidity problems and a holistic view on the total energy consumption is lacking. Other interviewees from research as well as industry stated that mould problems have nothing to do with energy-efficiency and that the mould discussion has been started and is strengthened by the media. However, according to an interviewee from industry, because the sector is risk averse this kind of discussion creates a barrier for building more energy-efficient buildings; hence the lack of knowledge is retarding the development and shaping the system.

Knowledge diffusion

There are challenges in the delivery of information about sustainable buildings to companies and home buyers (Häkkinen and Belloni, 2011). According to the interviewees from research, government and industry, while discussion about sustainability in buildings has increased, there is still a problem in the diffusion of knowledge from research and development to practice. The interviewees stated that the education lacks a holistic vision about the energy efficiency and renewable energy, and is often not up to date; as an example the interviewees raised the issue of the lack of education material.

Guidance of search

The value chain of building energy-efficient buildings using and producing renewable energy is sequential and fragmented (Similä, 2009, 96). There seems to be a lack of vision and strategy when it comes to energy solutions in housing districts on the one hand, and energy-efficiency of a building on the other. Technology developers and societal actors stated that the energy efficiency of a building is not seen as a whole. This means for instance that the integration of heating and cooling needs are missing (the house is heated and cooled at the same time), increased insulation increases the cooling demands, the air conditioning is not controlled optimally, different separate technical systems are not integrated etc.

According to the interviewees and participants of the workshop, the energy issues of the district or in the whole city are not seen as a whole and there is also a lack of general vision on the district level. One interviewee from research also stated that the renewable energy and energy efficiency issues should be considered also on the city level. There seems to be little interaction between the energy solution providers, home automation system providers, builders, city planners etc. The municipality guides the development of the region through the city plan on a general level. More specific guidelines can be given in plot conveyance conditions, which could be related to e.g. the calculated energy efficiency of the building. However, as these pertain to individual plots, the plots are often developed separately without the whole area in mind.

The views of the industry and municipality differed in how strict guidelines should be set. The city officials in the workshop stated that they prefer flexibility in the range of energy solutions, so as not to favour any specific company. As a result there is often no overall energy production plan for the area and each builder has to decide which energy source to use. The energy solution providers on the other hand stated that this creates too high a risk for them, as it is not guaranteed that all builders will choose the energy solution offered by the entrepreneur. Thus the renewable energy providers are reluctant to invest in energy solutions for the area.

While there is usually little interaction between city planners and the construction companies, there are good exceptions, such as the cooperation between the construction company and Tampere in Härmälänranta (see also Nykänen et al., 2007). In addition, the construction companies interviewed told that they do a lot of cooperation with different companies and increasingly also with city planners. The workshop participants and the study by Häkkinen and Belloni (2011) both emphasized the role of public actors, usually the municipalities, as coordinators and forerunners.

The interviewees from research also raised the issue of a lack of financial instruments to support the adoption of renewable energy solutions and stated that the general governmental policy has been not to subsidise any specific energy alternative. Also the role of consultants in designing the regulation is seen to be too big; the consultants have too much power in shaping the system over research.

Market formation

According to interviewees from the industry, there is a stated demand for energy-efficient buildings both from developers and inhabitants. Even though minimizing the energy use and environmental impact of the buildings sector is generally seen to be important, the construction companies interviewed stated that the economic and other criteria usually weigh more for customers. This was also confirmed in the survey with customers; renewable energy costs hinder the use. However, in another study higher cost of sustainable buildings was not seen as a major barrier (Häkkinen and Belloni, 2011).

In the discussion seminar we argued to the audience that based on our analyses the most powerful change agents in the sustainable construction industry system are the construction companies and the municipalities. The audience however strongly expressed that also customers, that is the occupants and citizens could also have the power to influence and change the system. However, in the survey the customers expressed that municipalities have power to shape the paths of the energy development, and customers by themselves have little power in decisions concerning it.

Researchers interviewed raised challenges related to a single consumer feeding electricity into the grid. From a technological side these challenges include the development of the electricity grid to better handle small decentralized power generation by e.g. more intelligent grid and better energy storage solutions (Airaksinen et al., 2013).

On the policy side the interviewed researchers stated that the lack of feed-in tariffs makes e.g. solar electricity generation in buildings unattractive and hinders the creation of markets for renewable energy solutions for buildings. In the survey solar energy was indicated an attractive renewable energy option by the consumers.

The comparison of the passive house markets in Austria, the Netherlands and Finland showed us that an integration of different policy sectors may cause a positive impact in market formation. For instance in Austria the passive house markets have been opened up in social construction projects, hence, by integrating innovation policy, climate policy, energy policy and social policy.

Resource mobilisation

The interviewees, workshop participants and literature reviewed (see e.g.Wessberg et al., 2013; Häkkinen and Belloni, 2011) all raised the issue of a lack of skilled labour in the design, construct, use and maintenance of energy efficiency and renewable energy solutions in buildings. This was seen to be one of the key barriers in the adoption of renewable energy in buildings. One cause for this was seen to be in the knowledge infrastructure, namely the fragmented education. Without skilled labour to design, install and maintain the systems, they are not used optimally and therefore the gains seem smaller. The availability of service business in renewable energy and energy efficiency might be a critical issue in the future. According to the survey customers value easy and reliable energy systems. They also expressed that they know where to find services, if needed. However, they were not so keen on attending the energy solution planning process of the district, nor to participate in an energy cooperative for a district.

Creation of legitimacy

The Ministry of the Environment is a key actor in Finland influencing the use of renewable energy and energy efficiency in the construction industry by setting the regulations on energy efficiency and building. According to interviewees from the research, the research institutes and universities could have more power in the sector, but it seems that the role of consultants and industry lobbyists have strengthened in recent years. The Ministry of the Environment has used the help of consultants when drafting new energy efficiency regulations. This, coupled with the rapid change in regulation has decreased the desired impact of the regulation according to the interviewees.

Researchers interviewed also stated that due to the relatively conservative and risk-averse attitudes of the construction industry, new solutions are often not trusted. This is especially true when it comes to insulation and passive or zero-energy houses, where concerns about mould lead to construction companies sticking to old, tested practices. It is also noteworthy that in Finland the construction company is responsible for the building technology at least 10 years after the building process, in serious problem situations even longer. The interviewees from research emphasised that this causes of course a bias against experimentation.

Interviewees from research, industry and government mentioned that the actors in the Finnish building sector are rather conservative and resistant to change. This is of course quite common in construction industry in general (Squicciarini and Asikainen, 2009). Generally the interviewees stated that there has been change in the attitudes in the last 10 years due to the pressures from regulation and the changing attitudes of end users. However, the use of renewable energy and energy-efficiency is not the common practice.

As the changes in regulations also show, energy-efficiency and sustainability became more prominent in the discussions about building in the 2000s. According to interviewees from industry, research and government, 15 years ago energy-efficiency was not a central theme in the discussions in the building sector, but now it is on the agenda of every company, even if only as a mention. Also the results of the survey signalled that consumers are aware of energy-efficiency, and they feel that low-carbon economy is important to achieve. The attitudes, habits and routines are changing slowly, and to a large extent the change is pushed by the regulations. According to interviewees from the industry and research, most of the construction companies are only fulfilling the minimum requirements set in different regulations.

Conclusions and policy implications

A key point in using the functions is to understand the interrelations between them. However, as there are differences in opinions of the actors, there is no single understanding of the barriers and drivers. Therefore we will analyse which aspects the different interviewees from industry, research and public sector emphasise. We feel that by presenting different views, we achieve a richer, if not comprehensive, basis on which to base policy recommendations.

The interviewees from the industry tended to emphasise the technological lock-ins, misguided regulations and the lack of demand for energy-efficient buildings or renewable energy solutions. They stated that they would be willing to make more energy efficient buildings and districts that use renewable energy solutions (and some companies indeed are doing that to some extent), but since there is no market demand or support from policy makers in the form of financial incentives, they have to stick to what is feasible for the company. The energy efficiency regulations were seen as disconnected from reality and not that helpful in decreasing energy use and increasing the share of renewables.

Interviewees from research also emphasised the problems in regulation, but more from the viewpoint that they had been left out and the regulations were not based on evidence from research, but rather on the lobbying from industry via consultants. In additions, they felt that policy instruments used were lacking or insufficiently funded, a view shared by the respondents of the survey. Interviewees from research also stated that the industry is too conservative in adopting new solutions and has trouble keeping up with the rapidly changing regulation. In other words, the researchers felt that they don't have a say in regulations or the solutions used by industry.

Societal actors interviewed emphasised problems mainly in coordination and connections between different actors. They stated that the value chain of the building sector is too fragmented and there is a lack of service providers to maintain new solutions, a view expressed also by the researchers interviewed. It is worth noting that the societal actors interviewed did not raise issues of technological lock-ins or problems in regulation.

All of the interviewees stated that there are problems in the diffusion of knowledge and coordination between the actors. However, they had different ideas on how to solve these problems. While the representatives from the municipality preferred a flexible plan so as to not favour any specific company, the companies saw the flexibility as too high a risk. However, there was general agreement that if there would be a coordinator ensuring the knowledge diffusion and overall view related to energy efficiency and use of renewable energy, it should be from the public sector.

Overall, the key findings in our research, and our policy recommendations, are six change paths, which will formulate a roadmap to a smart energy efficient city building (Figure 2, for the path method see also Kohl et al. 2014). These paths are:

1. Developing education and communication related to renewable energy and energy efficiency (courses and education material)
2. Changing attitudes (mainly by education and communication)
3. Creating service business around renewable energy and energy efficiency solutions (financial subsidies)
4. Developing collaboration between public and private actors (new modes of operation)
5. Creating integration of different policy sectors (innovation/climate/energy/social policies)
6. Managing the whole in all levels: house level, district level, city level (understanding gained mainly by education and communication as well as experience and research).

So, our policy recommendation is to have policy supporting renewable energy and energy efficiency education and research system as well as service business creation, public private collaboration and policy integration in renewable energy and energy efficiency sectors. These developments may help us to understand the renewable energy and energy efficiency in housing as a whole and therefore also show us how to manage the system wisely as a whole.

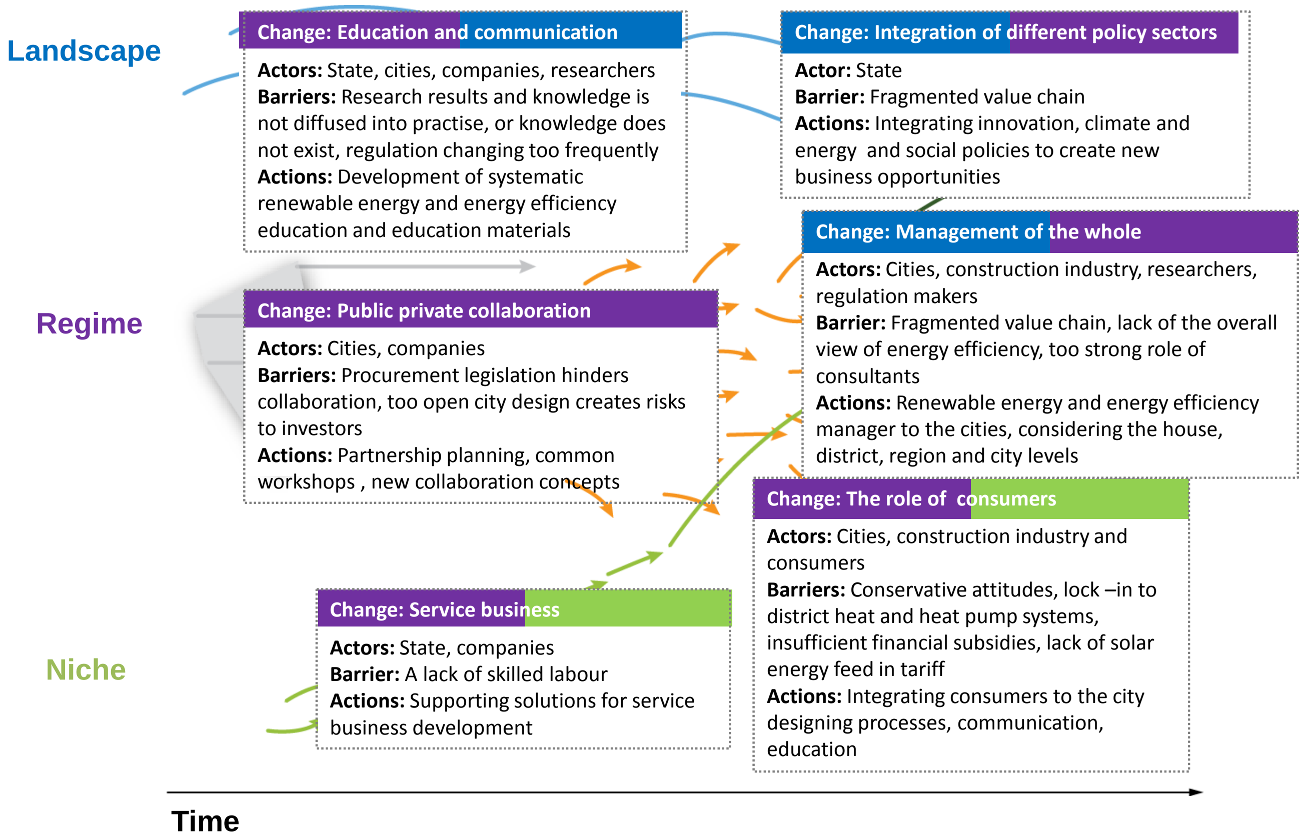

Figure 2. Six change paths: a roadmap to the vision of smart energy efficient city building – policy recommendations.

None of these six paths can change the system alone, but the system change is a result of changes in different levels and paths. For instance, education and communication shape attitudes. On the other hand, without education and communication we cannot obtain skilled service business, and without skilled service business the whole system of renewable energy and energy efficiency is not working. Likewise public private collaboration and management of the whole are dependent on education and attitudes; Integration of different policies also requires knowledge and understanding.

The diffusion of knowledge is also related to the need for improved and better integrated education on sustainability in the building sector. However, a more detailed analysis of the changes needed in the education was beyond the scope of this paper, and will be an interesting topic for further research. In general the promotion of renewable energy and energy efficient housing requires a clear will for a national policy and public debate, but also regional and national level guidance and concrete measures. This means co-operation and co-ordination between Ministries, regional governance and among other societal actors. In addition to a close collaboration among administrations, also supplementary and streamlined education on energy efficiency would be needed. On the business side, the development of services as a part of businesses and a delivery of comprehensive products and service business concepts are among key focuses in renewable energy and eco-efficient housing.

The development of renewable energy and energy efficient housing is necessary in mitigating global greenhouse gas emissions and in shifting energy production and consumption structures towards sustainable development path. Transition towards renewable energy and energy efficient housing in Finland has many key elements for successful future, such as advanced innovation system, strong traditional competences in bioenergy sector, and research and development activities and advanced innovation system and related policies. However, there are also many challenges such as those discussed in this paper. Overcoming these challenges requires a systemic understanding of the current situation. We hope the approach presented in this paper will be of help in gaining this systemic understanding.

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Towards a Bright Future? The Systems Intelligent Perspective on the Management of Light Pollution

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Light pollution caused by extensive or excessive use of electric lighting has become a global environmental change that profoundly alters the nocturnal environment. Various ecological and health effects are caused because of the disruption of natural cycles of light and dark. Energy production for lighting is also an important source of atmospheric carbon dioxide. The night-time emissions of light have increased rapidly during the past decades. This trend is likely to continue because of wide use of new lighting technologies, urban sprawl, population growth and economic growth. Efficient measures to address the light pollution problem are needed. Based on the results from a public online survey, the household-level efforts aimed to reduce light pollution are reviewed and possible obstacles of action are discussed. The concept of systems intelligence is proposed as useful approach for light pollution management. Systems intelligence builds from systems thinking. It emphasizes personal and active involvement with systems characterised by complex cross-scale interactions and non-linear feedbacks. Systems intelligent approach may be the key for future energy-efficient and low-carbon outdoor illumination that enhances human well-being while producing minimum amount of light pollution.

Introduction and Background

"For eons people have gazed at the skies and seen into their souls."

– Lisa Simpson[5] *–*

The Earth is facing different but intertwined global environmental changes caused by various human activities. The increase of night-time artificial light is perhaps the most easily observable global environmental change, but it has received only minor public and scholarly attention if compared with challenges such as climate change. During the past century natural darkness has disappeared from almost all habituated regions. Cinzano et al. (2001) estimated that one sixth of the world's population lived in areas where human eye is not capable of developing full night vision because of outdoor exposure to artificial light. This estimation was based on the satellite data from 1996/1997.

More recently, Victor and Ausubel (2007) produced maps illustrating how bright the night would look like if everyone in the world emitted light equalling the median per capita upward flux of artificial light of the U.S. citizens. These maps suggested a potential for massive increase of light emissions from densely populated countries, particularly in South and East Asia. Despite this, the authors concluded with an optimistic outlook: "Fortunately, more efficient illumination will surely lower the wasteful emission of light and the energy to produce it long before everyone lives like present Americans." (Victor and Ausubel, 2007, 77).

Unfortunately, it appears that this optimism was largely unfounded. Recent results based on satellite data show that between 1992 and 2009 both India and China experienced approximately 20% increase in the number of

[5] TV-series *The Simpsons*, Season 14, Episode 16: "Scuse Me While I Miss the Sky". First aired March 30, 2003.

outdoor lights and about 270% increase in the lighted area (Small & Elvidge, 2013). The use of light typically increases together with economic affluence and in many cases the increase of light emissions outpaces the economic growth (Ghosh et al., 2013). The global aggregated emissions continue to increase. However, in some industrialised countries the emissions appear to be stabilising or even decreasing, in addition to the Eastern European countries where emissions generally decreased following the collapse of the Soviet Union (Bennie et al., 2014; Cauwels et al., 2014).

Professional and amateur astronomers have repeatedly attempted to cast attention to light pollution. The success has been limited, except for some locations near important astronomic observations sites (Luginbulhl et al., 2009). During the past years, light pollution has also been brought up by various campaigns such as Globe at Night (www.globeatnight.org/), articles in popular magazines (Owen, 2007; Klinkenborg, 2008), web-pages (see e.g. www.ida.org), TV-documents (Cheney, 2011; McNamara, 2011), books (Posch et al., 2010; Mizon, 2012; IDA, 2012; Lyytimäki & Rinne, 2013a), academic commentaries (Gaston, 2013) and fictional TV-series such as *The Simpsons*. Despite these activities, the public awareness about light pollution is not wide-spread and stringent abatement policies are only rarely implemented (Falchi et al., 2011).

Astronomical aspects have dominated the light pollution debate. In addition to "astronomical light pollution" affecting the night sky, the concept of "ecological light pollution" has been coined to highlight the effects of artificial light on the nocturnal nature (Longcore & Rich, 2004). Very weak light can disturb organisms that are adapted to low levels of night time natural light. The documented cases include various effects to terrestrial and marine organism as well as avifauna (Rich & Longcore, 2006). Most of the knowledge concerns individual level effects. Only few studies on ecosystem-level effects have been published (Davies et al., 2013) and the effects to ecosystem services remain largely unstudied (Lyytimäki, 2013). Moreover, the long-term cumulative effects of light pollution and other environmental changes such as climate change are poorly known. However, the existing knowledge is sufficient to justify the actions aimed to reduce light pollution (Falchi et al., 2011; Lyytimäki et al., 2012).

Here the focus is on the role of individual human actors in the management of global environmental issues such as light pollution. Systems intelligence is proposed as a promising approach for the management of the light pollution. The paper is structured as follows. First, based on the data gathered via an online survey, the repertoire of voluntary household-level light pollution abatement activities in Finland is reviewed. This data allows an analysis of the public perceptions of the possibilities of individual human actor to influence and manage large-scale environmental changes. Second, the concept of systems intelligence is employed to discuss how to enhance future-oriented environmental management. Finally, some practical recommendations for the future-oriented environmental management aiming to connect individual human actions with the functioning of large and complex systems are made.

Material and Methods

Empirical data for this study originates from an online survey that aimed to chart the public opinions about the loss of darkness and light pollution. The survey was conducted in Finland with a Finnish-language web questionnaire. The objective was not to collect a representative sample of the population but to reach those Finns who are interested about light pollution and explore their views. The Finnish context of the survey is important to note when interpreting the results. Finland is a sparsely populated and relatively recently industrialised country that has small but extensively illuminated cities. It is a northern country characterised by high annual variability of natural light. The survey was conducted during the winter period of scarce natural daylight (24 November 2011–29 February 2012). The weather was milder than average and snow cover reflecting both natural and artificial light was absent from the southern Finland during the first half of the survey period. The winter storms of 26–27 December 2011 caused exceptionally large and long-lasting blackouts.

Over two thousand (N=2,053) responses were received. Most responses were obtained from southern Finland cities and towns. The respondents were well educated since 43.4% of them had university-level education. The majority (54.6%) of the respondents were male. The average age was 41.8 years. The capital, Helsinki, and the surrounding metropolitan area accounted for a third of the responses. However, the geographical coverage was wide, since responses were received from 67% of the 336 Finnish municipalities. Most of the respondents lived in residential areas of apartment buildings (29.3%) or in neighbourhoods of single-family houses (36.2%), whereas fewer lived in city centres (17.9%) or in sparsely populated areas (16.5%). Almost a half (48.3%) of the respondents identified themselves as amateur astronomers or members of non-governmental environmental or nature organisations.

The survey included 20 likert-scale statements and three open-ended questions. The details of the questionnaire and online survey application as well as summary of the results are presented elsewhere (Rinne & Lyytimäki, 2012; Lyytimäki & Rinne, 2013b). Here the focus is on responses to an open-ended question: "Have you attempted to reduce the light pollution or exposure to the disturbing light? How?" This question was answered by 1,527 respondents. The average length of the answers was 14.9 words. The length of the answers varied from statements of few words to short narratives of about 50–100 words.

A qualitatively oriented content analysis was performed (Mayring, 2000; Krippendorff, 2004). The aim was to capture the full variety of the personal reactions to the light pollution problem as presented by the responses. The data was screened for expressions describing the possibilities of individual actors to influence lighting system. Both on the manifest content directly describing the actions taken and latent content indirectly pointing to such activities were sought for. Based on the initial screening larger classes of response types were outlined and iteratively developed through several rounds of reading.

Results

The results indicate that the respondents generally considered their possibilities to influence the overall light pollution situation as limited. Some of respondents stated that they have not taken any actions and a few noted that they did not consider light pollution as a problem worth of taking personal activity. Many indicated that they were unaware of meaningful ways of action. Especially those living in apartment houses suspected that there are no effective measures to mitigate the light pollution available for them.

However, a majority of the respondents informed about some activities. Various examples of actions aimed to reduce unnecessary use of lighting were given, most often related to the personal use of electricity (Table 1). Commonly mentioned measures included switching off unnecessary outdoor and indoor lights, avoiding over-illumination of private gardens and careful direction of the luminaires. Some respondents stressed that they do not use decorative lights at all and others emphasised that they do not use harsh, blinking and colourful decorative lights. The appropriate timing of lighting was seen both as a method for energy saving and a method for reducing light pollution. Automatic time switches were commonly mentioned. Motions sensors switching lights on only when there is someone moving outdoors were used in private gardens. In some cases the overly sensitive sensors caused disturbance since they were triggered by wild animals or pets. Over-illumination was avoided by favouring dim overall lighting and by installation of the lights that can be dimmed. Glare was avoided by careful direction of luminaires and by favouring indirect light sources.

Table 1.The variety of personal level actions taken by Finns to minimize light pollution.

Type of action	Examples
Prudent use of lights	Switching off outdoor lights during the night hours Use of time switches, movement and light detectors and dimmers Avoidance of blinking LED-lights (e.g. bicycle lights) Careful use of car headlights and fog lights Favouring dim and comfortable overall lighting Using bright lights only where and when absolutely necessary
Minimizing the exposure to light by forestalling light trespass or glare	Use of blinding curtains in windows Use of sleeping eye patches Building constructs or planting trees or bushes that block the light Using sunglasses or hats when driving or walking. Covering the signal lights of electric devices Closing the eyes or looking away from light source
Minimizing the exposure to light by changing own location	Avoiding over-illuminated places (e.g. city centres, holiday destinations) Changing the place of residence to the countryside Jogging and outdoor exercising in areas with no lighting Keeping insides in order to avoid disturbing light
Consumer choices	Avoiding the purchase of powerful lights and decorative lights Boycotting of fruits that have been grown in greenhouses Favouring of public transportation
Reducing the need for illumination	Timing of outdoor activities according the natural light Making use of the moonlight Using reflectors to mark safe routes Avoidance of night-time car use
Influencing the lighting decisions	Participation in housing cooperative boards Direct contacts with municipal authorities Direct contacts with those responsible of lighting (e.g. sport fields) Giving comments to the environmental permit processes
Getting accustomed to natural light	Teaching the children to cope without extensive lighting Learning away from unnecessary fear of darkness Spending a week without artificial light Favouring natural sources of light and candle light
Increasing awareness about light pollution	Writing letters to the editor to the newspapers Informing decision makers Discussions with neighbours and work colleagues Getting attention to the term “light pollution”

Note: the types of actions are listed in order of popularity (the most often mentioned examples at the top).

The responses typically concentrated on the private use of light even though street and road lights were considered as more common sources of light pollution and commercial lighting was considered as the most annoying form of light use. Attempts to influence on public or commercial lighting were mentioned only rarely. The probable reason is that the respondents lacked possibilities to influence on these light sources. For some respondents, avoiding places with heavy commercial lights was the only effective way to react to the problem. Several respondents proposed that the municipalities should dim the street lights or switch them off during the quiet night time but only few have made such proposals to the municipality.

The majority of respondents answered from the perspective of property owner and described their activities in their permanent homes or leisure homes. The summer residences are particularly important in Finland since there are about 500,000 summer residences in a country of 5.4 million inhabitants (OSF, 2014). These second homes are becoming better equipped and the extensive use of outdoor lighting is becoming more common. This may create controversies, particularly when heavily lit properties disturb those who seek for natural tranquillity from their summer residences.

Some of the respondents answered from the perspective of a tourist. A person who has spent the winter holiday in the Finnish Lapland gave a rare example of an activity directed to the public/commercial lighting. This respondent had asked the owner of the ski resort to remove the fuse of outdoor lights in order to allow the view to the night sky. This is also an example of technical issues making it difficult to switch unwanted lights off.

The work roles emerged only rarely. Some lighting professionals told how they have tried to combat against installation of searchlights directed directly upwards. An office worker told how she had tried to stop the night time illumination of empty office corridors, with poor success. Two teachers told that they discuss about the light pollution issue with their students.

Participation with non-governmental organisations was reported more frequently than actions in workplaces. This is partly explained by the high share of amateur astronomers and environmental/nature activists. However, the typical forms of activities of environmental NGOs, such as attempts to increase public awareness through campaigning, were only rarely mentioned. Only few respondents reported about direct contacts with local authorities, discussions with neighbours or public expressions of concern through writings in newspapers or social media.

Respondents with privately owned houses and gardens typically reported about activities related to their own use of light. The occupants of the apartment houses highlighted the methods of protecting themselves from obtrusive light. Curtains or Venetian blinds were commonly mentioned but often considered as inadequate to completely forestall the light from streetlamps to enter the indoor spaces. Even though the occupants of the apartment houses generally felt that they lack the opportunities to make an impact, in some cases they had been able to reduce glare or light trespass by directly contacting the maintenance service responsible for lighting. Another method was the participation to the meetings of boards of the housing cooperatives where decisions about the maintenance of the apartment house are made. A key experience was that it is possible to have the luminaires redirected but it is nearly impossible to have the lamps removed once they have been installed.

Some respondents reported of being disturbed by extremely small amounts of light. For example, one respondent covered signal lights of all electric home devices in order to improve the sleep quality. Some respondents argued that in many cases it is possible to cope without any artificial light. One respondent concretised this with a humoristic tone: “I even sit in the toilet without lights because I know what to do without seeing”. Several respondents emphasized that it is important to allow the eye to adapt to low light levels and develop night vision (photopic vision). Using torchlights or other portable lights was considered adequate particularly during outdoor exercising or during night-time activities in the summer cottages.

Discussion and Conclusions

The results from our survey as well as insights from elsewhere (e.g. Mizon, 2012; Bogard, 2013) suggest that resignation related to ever-increasing light pollution is a widely shared sentiment among the people who are concerned about the issue. Challenge of reducing light pollution is often considered as overwhelming. It should also be noted that typically people intuitively consider the large-scale use of artificial light as a positive development (Morris, 2002; Lyytimäki et al., 2012; Edensor, 2013). The negative effects related to night-time light use are not self-evident for day-active species such as humans.

The concept of systems intelligence may provide an escape from the resignation. Systems intelligence builds from systems thinking. The key assumption of systems intelligence is that certain holistic entity deserves to be called "a system" and that the personal engagement in that system involves "intelligence" (Luoma et al., 2011). The approach emphasizes personal and active involvement with systems characterised by complex cross-scale interactions and non-linear feedbacks. The concept was first developed by Hämäläinen and Saarinen (2004).

Outdoor lighting can be considered as a holistic system that includes lighting technologies, infrastructures, human actions and values, as well as natural conditions. It is also characterised by a strong path-dependence where past decisions influence current situation. Lighting system is shaped both by technological development and human values and desires. Therefore, planning and management of a well-functioning lighting system is likely to require comprehensive knowledge base including value-based insights. Attention to the individual level determinants and dynamics of human action is needed since substantial part of light use and light pollution originates directly from decisions by private citizens.

A human acting with systems intelligence actively observes his/her interdependencies with the system and seeks for possibilities to improve the functioning of the system (Lyytimäki, 2006; Viluksela, 2007; Luoma et al., 2011). A person may act systems intelligently without consciously noticing it as such. As shown by some responses, systems intelligence is a natural capability of human mind, but it is often supressed by surrounding system. One respondent reported how casual discussions with neighbours that eventually lead to adoption of new and more restrained outdoor lighting practices throughout the neighbourhood. In this case, successful intervention was made through informal discussions with a friendly tone focusing attention to light pollution. This illustrates the importance of human sensitivity in social interaction that is one of the key characteristics of systems intelligent leadership.

Systems intelligence can be considered as an approach for preventing and managing conflicts that arise when different preferences of the use of night-time outdoor space collide. Several respondents reported about disagreements that were caused by different preferences, expectations and practices related to lighting. Increasing awareness of both the negative and positive impacts of artificial illumination can increase public understanding of the lighting system and alleviate or forestall the conflicts.

A key factor behind the controversies is the collision of commercial lighting and non-commercial uses of natural darkness. Artificial light is commercialised while clear night sky and other services provided by natural darkness are most often non-commercialised passive pleasures (Gallaway, 2010). Commercial lights are typically perceived as an indication of economic progress and welfare while decorative lighting signifies joy and prestige. Bright security lights may also give a feeling of control and safety even when they do not improve security or reduce crime (Marchant, 2010).

An important feature of systems intelligence is the search for systemic leverage points opening up positive development paths. Therefore, the emphasis of systems intelligent light pollution management is not on reducing light pollution but on improving the aesthetic quality of the built environment, increasing eco-efficiency and improving the security. As a side-effect, commercial opportunities are likely to emerge for manufacturers of high-quality lighting appliances.

Systems intelligence fostering a comprehensive public understanding of the impacts lighting systems may help to overcome the rebound effect. Historical examples suggest that more energy-efficient lighting technologies may lead to increase of overall energy consumption (Fouquet & Pearson 2006). A rebound effect, i.e. increased use of cost-efficient lighting technology is a likely future scenario also based on our survey. For many respondents, the financial savings were an important motivation for light pollution abatement, even though the electricity for outdoor lighting typically does not add much to the household's electricity bill. This motivation may become less relevant if the energy-efficient LED-based lighting continues to be more common. Awareness of light pollution may be needed in order to avoid the rebound effect caused by excessive LED-based outdoor lighting.

A focus on systems intelligence on a household level does not imply that the individual citizens are alone responsible for systemic changes. On the contrary, also the planners, managers, policy-makers and even the scientists can employ the ideas of system intelligence. Systems intelligence can operate in multiple levels. One example is our web-survey. Making a public survey about non-recognised issue such as light pollution is a method to frame the issue as a legitimate subject of serious discussion and action. In the best case, such survey produces useful data for scientists and simultaneously encourages the respondents to open their minds for alternative perspectives, systems implications and potential solutions for the problems encountered (Lyytimäki & Rotko, 2005).

Development and implementation of new technologies, lighting standards and legislation aiming to curb light pollution are clearly needed (Hölker et al., 2010; Falchi et al., 2011; Gaston, 2013). In addition, bottom-up activities of private citizens are an important part of the light pollution management. Systems intelligent approach may be the key for future energy-efficient and low-carbon outdoor illumination that enhances human well-being and produces minimum amount of light pollution. In the case of lighting system the systems intelligence helps to bring together several approaches and traditions of managing the system. It connects the scientific knowledge based on observing, modelling, theoretical reasoning and conceptual thinking with everyday experiences and choices. It also connects culturally and socially shaped attitudes and values with management practices and institutions shaped by technical reason and legislative rationalities. Finally, it helps to bring together contradicting values and targets in a positive and even synergistic ways. In the best case, systems intelligent behavior of a single human actor may enhance systemic local level changes that eventually lead to changes in national and even global level.

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Challenges of Building Governance for the Complex Spatialities of the EU's Biofuel Development: A Topological Investigation

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Based on a topological approach that studies law, policy and space intertwined, I present an analysis how the renewable energy governance of the European Union (EU) has influenced the development of transport biofuels globally. The instruments of governance regulate the spaces of producing, consuming and trading biofuels. On the other hand, the rapid development of biofuels has created externalities, impacts that are mediated from these well-governed spaces into other locations, which I discuss under the rubric of the dislocated spatiality of biofuels. I use this concept to explicate the shortcomings and challenges that are not tackled by the EU. Moreover, my analysis reveals how the recent biofuel policy of the European Commission is increasingly built on a set of instruments that are grounded through the calculation of greenhouse gas emissions. This re-orientation does not only denote a drastic change in logic of promoting biofuels in the Union but also it shifts the focus from governing actual actors and elements associated with the EU's biofuel development into quantitative realms construed through models.

Introduction

The European Union (EU) is currently the largest importer of biofuels in the world, which is why the evolutions in the Union's framework of governing biofuels are dispersed around the globe. The production, trade and consumption of biofuels associated with the Union are steered through political and legal instruments, such as trade and state aid regulations, directives, strategies, funding instruments, standardizations and obligations. The research strategy of this article is to focus on the manifold ways this multi-sectorial framework of governing biofuels is associated with the spatiality of their development that exceeds the borders of the EU, which has not been researched as a whole. I aim to demarcate the key actors and elements of the Union's biofuel development that are being governed through the laws and policies of the EU and, further, to unfold the spatialities where the governance is still being formulated. Subsequently, studying the governance of biofuels is about studying the intertwining of policy, law and space.

For this purpose, I introduce the key concept of my analysis, *topology* that refers to a certain type of spatial understanding according to which space is approached through the relations between actors and elements (DeLanda, 2006, Latour, 2006, Jones, 2009). Accordingly, objects are not distributed in space *as such*, but they are the very constituents of space. Using the metric spatial understanding, for instance in explicating the total surface area required to meet the EU's biofuel consumption in 2020, cannot reveal the complex network of different actors, institutions, funding instruments, trade regulations, the greenhouse gas (GHG) emissions of land-use changes that are associated with every singular land acquisition (e.g. Sassen, 2013). Topological analysis necessitates studying the EU's instruments of biofuel governance as associated with the heterogeneous elements that range from laboratories examining ways to convert lingo-cellulose into sugars to the subsistence farmers impacted by the land acquisitions in Mozambique. In other words, my topological analysis does not simply map different practices related to the EU's biofuel development but it also unfolds how those are related to each other and to the political and legal instruments governing them. Indeed, law and policy do not operate without agency that mediates them into practices and enforces their implementation (Delaney, 2010). In my earlier research, I have used versatile materials and methods to recognize actors and other elements associated with the EU's biofuel development (e.g. Humalisto & Joronen, 2013, Humalisto, 2014a, 2014b). I use those materials also as the basis of the topological analysis of this article.

I argue in this article that there are two fundamentally distinctive, but nonetheless interlinked spatialities related to the EU's biofuel development. The first ones include production, trade and consumption, in which the instruments of governance have assembled tight and well-functioning relationships between actors and elements (see Table 1). The second spatiality I discuss under the rubric of dislocated spatialities where the governance of biofuel development is still being formulated. To avoid misapprehensions from the beginning, I do not wish to claim that these spatialities would be distinct. On the contrary, robust customs fees cause smuggling. Land-use changes for producing biofuels can relocate the original practices of land-use. The consumption of even sustainably certified biofuels can reduce resources from other industries. Subsequently, governed and non-governed are tightly associated with each other.

Spaces of established governance

Spaces of production

As the clear majority of biofuels consumed around the globe are crop-based, *first-generation* traditional biodiesel and ethanol, the sites of agricultural production remain still the key spatialities related to biofuel development. Brazilian sugarcane, corn from the United States (US), European rape oil, sugar beet and wheat, soy from Argentine and palm oil from South-East Asia are among the most used crops as the feedstock of the biofuels consumed in the EU. The main products refined from these feedstocks are ethanol and biodiesel. The topological form of the production is most often an industrial plantation monoculture where production is highly intensive, well governed and measurable – both in the Industrial North and Global South. These monocultures are associated with trading agricultural commodities and internationally operating financing systems. The EU itself and several researchers have pinpointed that the biofuel development has strengthened this model of production, which nonetheless, was not among the aims why the Commission began to promote biofuels (e.g. Smith, 2010). However, safeguarding the agriculture from intensification has not received the ambitious instruments of political or legal steering and the actual biofuel development of the Union has been connected to the existing agro-industrial complexes. Companies like Cargill, Archer Daniel Midlands (ADM), Diester Industrie that are well known actors in the agribusiness are also among the biggest biofuel producers operating in the EU. These large scale, globally operating companies connect the localised assemblages of agriculture with EU biofuel development through trading feedstocks and fuels, funding international research projects and participating certification initiatives.

Consequently, biofuel development has not generally de-centralized the production models of energy or agriculture. Supporting subsistence farmers of the Global South through biofuels, which was outlined in the EU biofuel strategy (CEC, 2006) has not played out either. Instead, there has been increasing amount of land acquisitions discussed under the term 'land grabs' made by companies and investors operating on a global scale and it remains unclear whether these types of investments benefit anybody else than local elites (Cheru & Modi, 2013). Initiatives such as out-grower schemes that might improve the security and environmental performance of agricultural production, and group certification promoted by certifying bodies have not gained popularity concerning the agricultural spaces of production of biofuels (Lee et al., 2010).

The EU has had a significant role in supporting the emergence of the agricultural spaces of biofuel production. The Union began its biofuel policies with a directive that made it possible for the Member States (MS) to propose tax exemptions for biofuels (EC, 1992). The role of domestic agriculture was further encouraged by the reform of the Common Agricultural Policy (CAP) in 2003 making it possible to allocate subsidies for energy crops. However, despite these actual legal and other political instruments that have lowered the market access of biofuels, it was the Commission's strategies and action plans that originally grounded the use of crop-based biofuels. These instruments promoted biofuels not only for environmental, air quality and climatic benefits but further due to biofuel capacity to solve the problems of agricultural overproduction, support sustainable regional development, and in particular, enhance the energy security of the EU (Humalisto, 2014a). Concerning the future of the agricultural spaces, the Commission with its recent proposal concerning indirect land-use changes (iLUC) caused by biofuels and the climate and energy framework in 2020–2030, sedimented a transition from fields to other sources for feedstocks. The directive proposal suggests a cap for the share of crop-based biofuels eligible for subsidies that have played a crucial role in the market penetration of biofuels in the MS. Moreover, the Commission indicates that after 2020, crop-based biofuels should be phased out and no subsidies can be allowed for them as they cause iLUC by displacing originary practices of using land and threaten the global food security by increasing the volatility of the food markets (Laborde, 2011; OECD/FAO, 2012).

Concurrently to the plummeting popularity of crop-based biofuels, the Commission has given special focus to develop the spaces of production associated with wastes and residues that do not require land or directly compete with food production. These advanced, *second-generation production pathways* have not contributed a significant proportion of the world biofuel production – although they might be nationally or municipally important (Humalisto, 2014b). Actually, the opposite has taken place: their commercialization has been slower than expected. Even biogas, refined from wastes and residues, has received limited attention in the MS; except in Sweden. These spaces of production are associated mainly with food industry by-products, municipal wastes, and forest and pulp industry residues. These feedstocks tend to have better energy and GHG performance than agricultural crops. Topologically, these actors offer both centralized and decentralized solutions. Swedish biogas municipalities are illustrating the dispersed model of producing advanced biofuels while the biomass-to-liquid projects operate in larger scales in close co-operation with pulp industry. Nonetheless, concerning the material elements within the EU, wastes and residues can provide only a partial solution as pine oil, for instance, is used in chemical industry (Kampman et al., 2012). Additionally, sustainable waste policies orient in *reducing* the amount of wastes instead of *increasing* it.

Albeit being satisfied with the increasing use of crop-based biofuels until the late 2000s, the Commission has simultaneously funded the research, development and deployment of advanced biofuel technologies in transport during the last two decades. The industry actors, however, argue that even though the Commission has favoured advanced biofuels, the political and legal instruments have not been strong enough. In other words, the framework of biofuel governance has legitimized the transition towards advanced biofuels but the instruments for making this transition have been somewhat inadequate. Indeed, advanced refining technologies have not yet challenged the EU's dependency on crop-based biofuels.

Though there are no biofuel refiners that currently produce so called *third generation* biofuels from laboratory engineered algae or microbes on a commercial scale, I find it important to introduce these spaces as their emergence is backed up by the EU's instruments of governance. The actors of these spaces are not only the leading biofuel companies that are financing university based and other research units around the globe to find suitable technologies. Also chemical industry giants, such as DuPont and Syngenta play their part. These companies have long experience of genetic manipulation and other techniques that can solve the existing obstacles to market penetration.

Spaces of trade

Biofuels are traded globally through the already existing transport infrastructures, unlike other forms of renewable energy. Although finding accurate information concerning the quantities and origins of the consumed biofuels in the Union are difficult to trace as only rare MS require the information about trading to be transparent and several companies consider their trade relations as business secrets, it is certain that the EU imports of biofuels have grown. The most recent estimates concerning the imports are 20% percent for ethanol and 33% for biodiesel (Systemes Solaires, 2013). Prior to the emergence of these global biofuel and -mass trading networks in the mid-2000s (Mol, 2007), the internal energy markets of the Union constituted a significant target for the Commission's legislation; and they still do (compare CEC, 1995 with CEC, 2014). Concerning biofuels, the key element of guaranteeing the functionality of internal markets has been the increasing harmonization of taxation on biofuels in the MS. Moreover, the EU has guaranteed the global trading of biofuels through the stronger standardization of the different biofuels (Humalisto, 2014a).

As a consequence, the oil distributors have become more dependent on imported biofuel and -masses since the origins of the EU's biofuel development (Humalisto & Joronen, 2013). Certainly, tropical alternatives are more lucrative because the labour and land are cheaper, average yields are considerably higher and there is still much potential in developing more intensive forms of agriculture. Nonetheless, this increased mobility and flows require more or less stable spatial formations and institutions to regulate and govern these flows (Urry, 2003). For example, the harbour of Rotterdam, specialized in the logistics of palm oil transport, has increased its significance. Hence, the topology of trading biofuels is partly developed on the existing patterns and the companies who have been deeply involved in the trade of agricultural products prior to biofuels. Cargill and ADM, for instance, that both are major operators in refining biofuels in the EU are part of the agro-industrial nexus with Bunge and Luis Dreyfus that control 75–90 % of the global trade of grains (Murphy et al., 2012). The EU has strengthened the global trading networks by taking biofuel into its free trade negotiations that have increased the mobility of biofuels. What is more, the Commission has pinpointed in its strategies concerning the biofuel development that it can be beneficial for the developing countries to produce feedstocks to the growing markets of biofuels.

Against this backdrop, the EU's governance of the trade of biofuels has been somewhat schizophrenic as the legislation and policies governing trading have supported 'free markets', but simultaneously, the imports to the EU have been regulated by trade barriers and other instruments. Notwithstanding clearing obstacles of making investments in the Global South, the Commission has implemented instruments that have supported the domesticity of production and consumption due to agricultural and biofuel lobby groups against the interests of the producers of the Global South and biofuel importers in the EU. Prime instruments have different trade barriers, namely keeping up high customs fees for imported biofuels (Systems Solaires, 2012). For instance, the EU was protected against the subsidized soy oil from the US by imposing a provisional anti-dumping duty on the imports of biodiesel originating from that country (EC, 2009b). This regulation, for instance, has proved out to be an efficient border as biodiesel feedstocks were imported mainly from two countries: Indonesia and Argentine, constituting together 90% of all imports (EurActiv, 2013). Nonetheless, the Commission implemented a strong antidumping regulation concerning also the biodiesel imports from Indonesia and Argentine (EC, 2013). The domesticity has also been protected through standardization that favours the biofuels produced from the European feedstocks (Humalisto, 2014a).

Spaces of consumption

The EU has construed a framework of governance for the consumption of biofuels in its MS. The Union has not supported biofuel commercialization only by enhancing their economic feasibility in relation to fossil fuels and removing of the (internal) trade barriers. Since the origins of biofuel policies in the EU, the Commission has encouraged increasing consumption of biofuels by harmonizing the spaces of biofuel consumption in its MS. The rapid growth of consumption in the EU followed the implementation of the Biofuel directive that set indicative targets for the share of biofuels in transport: 2% by 2005 and 5.75% by 2010 (EC, 2003). This directive associated the MS tighter with the EU's biofuel governance as they were mandated to establish the national biofuel action plans to introduce the mechanisms of biofuel promotion and the Commission was keen to use its juridical powers to ensure that this integration did indeed occur. The Commission, however, saw that the indicative target was not a strong enough mechanism to guarantee the penetration of biofuels as only Sweden and Germany were able to reach 2% target of 2005. Subsequently, when the Commission introduced the 10% target for the share of renewable energy in transport in 2020, it was mandatory (EC, 2009a).

Despite the harmonization efforts of the Union, the topologies of biofuel consumption in the MS are unique, because the constellations of the actors who actually are involved in reaching national targets are diverse. In other words, the MS *as such* do not launch the consumption of biofuels, but nonetheless, national legislation can create a framework that supports the all-European targets. It is fuel distribution companies that hold a key position, for instance, in implementing the blending mandates concerning E5 or E10 but the distribution of pure blend biofuels like B100, E85 and biogas requires a wider set of actors to co-operate, subsequently increasing the topological complexity. The launch of pure biofuel consumption requires the simultaneous take-off of biofuel production, consumption and distribution – in Sweden for instance, building associations between oil companies, car manufacturers and municipalities. Their municipally originated national policies and laws have included instruments such as the procurement policy of cars that use the pure blends of biofuel, the funding of biogas production facilities, the raising of public awareness, allocating privileges like opportunities to park freely of use bus lanes for alternative fuel vehicles and supporting oil companies in making changes in their fuel distribution infrastructure (Humalisto, 2014b).

Indeed, the implementation of the Commission biofuel targets diverges in the MS as the instruments are meshed into the national and sub-national constellation of actors and the frameworks of biofuel governance. The

Commission has actually supported this multi-approach increasing the consumption of biofuels instead of suggesting blending mandates alone, for instance, by making it possible to support the national vehicle procurement policies to favour biofuels. The direction of having more alternatives in transport fuels is further strengthened by proposing a directive that would make it mandatory for the MS to provide gas to secure the commercialization of gas vehicles especially in road transport (CEC, 2013a). Although biofuels are mainly used in road transport, the Commission's strategy concerning alternative fuels and Energy roadmap to 2050 argues that future of biofuels is in aviation, marine transport, rail and long distance road transport that cannot be electrified (CEC, 2011, 2013b). Thus, the framework concerning the spaces of consumption might be elaborated from passenger cars on roads to air, water and rail transport. How this expansion of biofuel can be achieved without compromising further the welfare of ecosystems, atmosphere or food security, will be discussed next through examining the dislocated spatialities of biofuel development.

Forming governance: dislocated spatialities

Latour (2005) stresses how all action is generated by and simultaneously influencing the environment where actions take place. Similarly, DeLanda (2006) holds that an event produces another event that is irreducible to the prior event. Drawing from these insights about the (spatial) entanglement of action, it is easy to recognize how the effects of biofuel development certainly exceed these above examined, well-governed spatialities, which I discuss under a general term of *dislocated spatialities*. With this concept, I refer to the multifaceted consequences of biofuel development that leak from the well-regulated topologies the EU's biofuel development. Biofuels emerged in the middle of the assemblages of forestry, agriculture, waste management and transport, which necessarily causes changes to the dynamics of these already stabilized entities. There was no 'empty space' waiting for biofuels to emerge, and subsequently the rapid biofuel development has dislocated and distorted previously existing processes. Certainly, among the purposes why the Commission began to craft the incentivizing framework of biofuel governance was the need to re-structure agricultural production; to solve its problems related to declining profits and overproduction. In other words, the indirect consequences of the biofuel development were, in some sense, among the reasons why biofuels became promoted in the first place.

Undoubtedly, the fast growth of biofuel consumption of the EU may have caused versatile negative indirect impacts, such as displacing subsistence agriculture by supporting industrial monocultures, encouraging to land grabs, accelerating tropical forest loss due to the increasing demand for vegetable oils, sugars and cereals cultivated in the Global South, the increasing volatility of the food prices by allocating food to fuel, and disastrous climatic impacts through land-use changes that are occurring in peat rich soils. In addition, these displaced spatialities do not concern only the elements of biofuel production: in 2010, Italian customs officers discovered an illegal cargo of 10 000 tonnes of subsidised US soy oil. Thaler (2013: 151) argues that Brazilian interest in developing the ethanol sector of Mozambique is rooted to desire to trade ethanol for European markets without high customs fees. Moreover, fuels have been imported to the Union through third countries to avoid custom fees. Economic operators have also discovered loop holes to import ethanol without custom fees as non-classified products under the combined nomenclature (Systèmes Solaires, 2011–2013).

The problems caused by biofuels clearly cannot be tackled with the same instruments that gave birth to them, and therefore the EU has needed to construe a new type of governance that does not simply encourage the increasing production, trade and consumption of biofuels. Currently, the attention of the EU's biofuel policy-making concerning the dislocated spatialities of biofuels is focused on indirect land-use changes – and, in particular, the GHG emissions that they cause. Therefore, the Commission began in 2009 to assess whether iLUC is significant enough that it should be governed. Scientific knowledge about iLUC was at that time minimal, and thus the Commission was obliged by European Parliament to introduce methodology of assessing the scope of this detrimental phenomenon. Surely, the agro-economic equilibrium models that were selected by the Commission to quantify the GHG emissions from iLUC under selected scenarios have made this phenomenon tangible enough to be taken into the spheres of the EU's policy-making. Nonetheless, what these models have *not* been able to accomplish, is to tackle the topological complexity of iLUC and the agency how these changes actually occur (Humalisto & Joronen, 2013). Further, the models have not explicated the factors that could dampen the likelihood for iLUC to occur (but for exceptions, see Lapola et al., 2010).

In other words, the iLUC policy-formulation has been transferred into a language of critique that has begun to tear down almost the whole framework of instruments designed to encourage the transition from fossil fuels to renewables in the EU's transport. What is revealed behind, however, is a calculative framework according to which actors are not considered to be capable of counteracting these potential negative consequences of biofuels. Indeed, this solution of the EU is somewhat contradictory to the results and policy-suggestions emerging from multi-disciplinary sciences of iLUC. The 'real' that these model-based policies of the Commission have unfolded, is, perhaps ironically, not populated by actual actors and elements that are influencing the EU's biofuel development. Therefore, the Commission has taken an easy way out: indeed, in the recent energy and climate framework in 2020–2030, there are no renewable fuel targets for transport. Thus the ostracizing does not concern only crop-based biofuels but renewable energies in transport as a whole. Certainly, this is an effective way to end dislocation by terminating all the processes that can cause it, but I feel that more discussions are needed to conclude whether the EU's transport (including also aviation, marine and rail transport) can become sustainable without any land-using organic feedstocks that can possible cause detrimental negative, dislocated consequences.

Discussions and conclusions

Indeed, what this topological analysis has shown is that the EU has construed an extensive framework of instruments governing the multiform spatialities of biofuel development. Biofuels are manufactured and traded around the globe, and moreover, the types of actors and elements associated with this development differentiate from each other, ranging from GMO laboratories to Ugandan peasant farmers. Surely, the successful launching of biofuel development has needed a considerable amount of assembling of distributions infrastructures, motor technologies, trading systems, taxation and into an entity capable of providing reasonably prized biofuels for European consumers. Nonetheless, this framework of governance is not without its contradictions. Not only do the aims why biofuels were promoted in the first place differentiate from the actual consequences of this development. The framework also has intrinsic contradictions. Point in case, the Union promotes the free trade of biofuels while concurrently establishes new trade barriers and the Commission highlights how biofuels could enhance the sustainability of agricultural protection without safeguarding agricultural production from increasingly industrialized models of production.

The EU has only after setting the obligatory 10% renewable fuel target began to recognize the importance of tackling the detrimental consequences caused by dislocating spatial impacts of biofuels. In the recent policy developments, the overall purpose of promoting biofuels has been unfolded through discussing about iLUC caused by the rapid expansion of crop-based biofuels. These dislocated spatialities are not easily tackled because of their indirect character. The EU's solution how to construe the governmentality of these multiform problems has been a deeper integration of biofuel policies with instruments focused on mitigating climate change. What might be characterized as the calculative politics of carbon (e.g. Humalisto & Joronen, 2013), has become the key element to assign relations in the versatile spaces associated with the EU's biofuel development. Accordingly, the EU, after modelling GHG impacts of iLUC, suggests that crop-based biofuels should be phased out after 2020 – albeit that the EU's biofuel development has been established almost solely on the consumption of these first-generation ethanol and biodiesel. What is more, the Commission has not introduced any renewable fuel targets for transport concerning 2020–2030. Assuming that crop-based biofuels are going to be phased out after 2020, it becomes evident that much of the existing infrastructure making it possible to manufacture, transport and consume biofuels becomes outdated. Additionally, this transition signifies the need to induce substantial investments that would make it possible to replace 13.6 Mtoe of crop-based biofuels that was consumed in 2013 with other renewable fuels (Systemes Solaires, 2014). When the EU pursuits almost completely renewing what biofuel development is about, I feel some of the challenges raised by this new mode of governing should be addressed.

First, the most direct concern is whether there will be enough feedstocks for renewable liquid or gaseous biofuels that are not crop-based? Surely road transport in some of the urban parts of the world can be electrified but heavy duty vehicles travelling long distances, aviation and marine transport cannot. However, these forms of transport also need feasible alternatives for their moving powers. I strongly support the better utilization of wastes and residues but the fact remains that they can satisfy only a fraction of the total demand for energy in transport. *Second*, one cannot design a more efficient way to stop the spatial leakage of negative, indirect consequences than the complete eradication of the processes that are causing them. However, by doing so, none of the reasons why these negative outcomes do emerge are being tackled. The iLUC models, for example, rather explicitly explicate that the high GHG emissions caused by vegetable oil associated land-use changes are due to the clearings of carbon rich peat swamp forests in front of oil palm plantations in South East Asia. Against this backdrop, the Commission's biofuel policy rejects the possibility that any enhancements could be reached through instruments in land-use planning. Therefore, the EU is not interested to develop further the environmental, climatic or environmental performance of the agricultural assemblages already associated with biofuel development.

My *final point* concerns how the expansion of agriculture could be sustainable without solving the issues of energy production simultaneously. Indeed, the growing agricultural production needs to solve its energy problems. Unsustainable and volatile energy production and consumption models weaken the social, environmental and climatic performance of agriculture and, furthermore, the food security on national and sub-national scales. Instead of treating biofuels and their dislocated spatialities almost solely as a question of climate change, the EU could re-think whether it wants to exclude the possibilities of crop-based biofuels to strengthen land-use planning, to increase the protection of vulnerable ecosystems or to support the rights of subsistence farmers to access land. These pursuits are already part of the EU's land-use, development and biofuel policies (e.g. EU, 2004; CEC, 2006; 2010). If strengthened and applied more often, the EU might be able to promote sustainable, integrated models for producing energy and crops. Moreover, according to International Panel on Climate Change (2014), enhanced land-use planning has the capacity to dampen negative iLUC impacts. Subsequently, I end this article by suggesting that the EU could gain multiple synergies through enriching its governance of biofuels with the instruments of land-use policy.

Table 1. Spatiality, aims and instruments of governing EU biofuel development

Spatialities of the development	Implemented policies and laws	Aims of governance
Production • Large scale industrial plantations of the South • Regulated sites of EU agriculture and energy crops • Municipal and food industry wastes and agricultural and forest sourced residues • Laboratories designing microbes and algae	• Tax exemptions for various biofuels to encourage investments in the sector • Research, development and deployment for the commercialization of versatile biofuel technologies • Common Agricultural Policy allocating subsidies for energy crops • Standardization of biofuels in order to ordain their functional relationships with the distribution infrastructure and motor vehicle fleets	• Increase the market penetration of biofuels • Enhance the energy security of the EU and mitigate climate change • Find advanced biofuel solutions • Support regional development and rural job creation • Ordain functional relationships between vehicles and fuels
Trade • Existing trading patterns of agricultural products and biofuels • Trade of technologies • Trade of land • Trade of carbon through Clean Development Mechanism	• Free trade agreements between the EU and other biofuel producing regions • Customs fees for imported biofuels and masses • Land-use policies • Transnational investments policies • Development co-operation • Standardization	• Dismantle trade barriers of the South • Protect domestic production • Make biofuel associated land investments more sustainable • Integrate developing countries to world trade • Make the trading of biofuels global
Consumption • Existing oil-based transport fuel networks for low blend biofuels • Emerging transport system of alternative moving powers (harbours and roads) • Differentiating consumer attitudes towards biofuels	• Tax harmonization (tax exemptions for biofuels made possible) • Biofuel and renewable targets for MS • Instruments for biofuel consumption increase (e.g. support for alternative fuel captive fleets) • Mandatory alternative fuel network construction	• Remove national barriers of biofuel market penetration • Guarantee safe investment environments for companies • Make infrastructural changes to fuel distribution and motor vehicle technology, thus enhancing the energy security of the EU
Dislocation • Multiform, often detrimental impacts dispersing from the governed spaces of the production, trade and consumption of biofuels	• Sustainability criteria • Instruments favouring non-crop-based biofuels and the utilization of marginal and degraded land • Land-use policy • Approved certification schemes for biofuels *Suggested instruments:* • iLUC factors (for reporting) • Cap for crop-based biofuels	• Target biofuel feedstock for non-land-using alternatives • Improve the utilization of marginal and degraded lands • Guarantee the climatic sustainability of biofuels • Safeguard forest biodiversity • Limit the interaction with biofuels and agriculture

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Building a Vision and a Roadmap for a National Transport Research Programme – Smart, Low-Carbon Transport System 2030

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The grand challenge of climate change has initiated numerous research programmes during the past decades. TransSmart, Smart mobility integrated with low-carbon energy, launched in the beginning of 2013, is one of them. The programme consists of four research themes: Low carbon energy, Advanced vehicles, Smart transport services and Sustainable transport system. To promote synergies within the TransSmart programme and to encourage new collaboration and novel research activities, a visioning and roadmapping exercise was set up. Based on that exercise, this paper proposes a future oriented, multi-level approach to Research and Development (R&D) programme management. The theoretical background of the approach stems from integrating insights from three fields, namely research on socio-technical change, roadmapping, and project management. The paper presents the working process and methods used and the results achieved in the developed, participatory approach. The main outcomes of the work are the programme-level vision of smart, low-carbon transport system 2030 and the system transition roadmap visualising research activities in reaching this vision. The most important contributions of our visioning and roadmapping exercise were found in the interaction the approach initiated between the different programme stakeholders. This covered reaching a common view on future developments and actions towards the vision, clarification of the individual programme theme contents, placing the programme into a wider societal frame that increased the commitment of the stakeholders to the programme and finally understanding the process as a mutual learning environment.

Introduction and Background

Research context

Climate change is a topic, which has brought about numerous research programmes during the past decades. This is the case also in the transport sector. Technological aspects such as contribution of various fuels and energy carriers to energy efficiency and consumption have often formed the hard core of the research programmes. Wider scope covering the entire transport system has received less attention, at least on national level, even though strategic planning and business development towards smart, low carbon transport futures would benefit from transdisciplinary, systemic and integrated research approaches.

TransSmart, Smart mobility integrated with low-carbon energy, is a spearhead programme launched in the beginning of 2013 as a platform for strategic research for transport at VTT Technical Research Centre of Finland. The programme consists of four research themes: Low carbon energy, Advanced vehicles, Smart transport services and Sustainable transport system. TransSmart pursues to combine knowledge and competences from its research themes widely to enable transport research to effectively facilitate establishment of collaboration, strategic partnerships and networks between the industry, the research community and the public sector. The outcomes of the TransSmart programme will contribute to reaching targets for transport greenhouse gas emission reduction and energy efficiency and to generating profitable domestic and international business activities.

Our main argument is that to be successful, a large, mission oriented research programme, like TransSmart, needs a strong future oriented management approach. Visionary roadmapping approach presented in this paper provides a contribution into that direction.

The contemporary Finnish context for transport and energy research can be described as follows. Transport sector is highly regulated through international, regional and national rules and regulations. International regulations relate to e.g. vehicle exhaust emissions and vehicle safety features. As regards the whole transport system, the European Commission (European Commission 2011) has set the preliminary greenhouse gas emission reduction target for the year 2050, which states that transport should cut its greenhouse gas (GHG) emissions by 60%. The task is very demanding since the number of vehicles and transport work are expected to increase.

Recently, great expectations have been put to information and communication technologies (ICT) to revolutionise the whole transport system. Intelligence will be embedded at all levels of the systems, in the vehicle with its subsystems, in the surrounding infrastructure, in the energy supply, in the management systems and in the services delivered by the system. As for energy technologies, it is difficult to say which will win the race: biofuels, the battery electric vehicle, the fuel cell vehicle or some other technology.

This paper is based on the first year management activities of the TransSmart programme. As a part of the activities, the programme management decided to develop a vision and a roadmap for the programme, with the aim of (1) linking the programme into a wider societal context, (2) supporting programme objective and target setting, (3) identifying research knowledge and competence synergies within the programme and (4) fostering new knowledge and business opportunities.

Theoretical background

The theoretical background of the paper stems from integrating insights from three fields. Research on socio-technical change (e.g. Geels 2002 and 2004, Geels & Schot 2007) provides a frame to consider transport system and changes needed in a wider societal context. Roadmapping, in the field of foresight, offers a tool to illustrate future developments in both the transport system and transport research programme contexts. Finally, the field of project management links the programme research themes into the practical programme and project work.

The socio-technical system of transport is a socially constructed entity that aims to fulfil the mobility needs of its users and in time reshapes the society. It consists of wide range of interlinked dimensions such as technologies, markets, users, science, policies, cultural meanings, etc. It is thus a web, consisting of these elements and resources to endorse them, like knowledge, capital and labour. A socio-technical system and its transition from one configuration to another can be studied using the multi-level perspective (MLP), which distinguishes three analytical levels: the niche-level that accounts for the emergence of new innovations, the socio-technical regime level that accounts for the stability of existing systems, and the socio-technical landscape that accounts for exogenous macro-developments (e.g. Geels & Schot 2007, Geels 2012). A major shift in a socio-technical system (in our case towards smart, low carbon transport system 2030) is realised when structural changes take place in the dimensions of the system. Research programmes like TransSmart may provide a platform for various actors to promote the shift.

Within the field of foresight, roadmapping is a methodology that has been applied in several industrial organizations in order to facilitate and communicate technology strategy and planning. Basically, roadmaps aim to provide an extended view on the future of a chosen field of inquiry (Kostoff & Schaller 2001). They provide a structured and often graphical means for exploring and communicating the relationships between evolving markets, products and technologies over time. Roadmaps can take a variety of specific forms depending on the roadmap type. They also make inventories of different possibilities, communicate visions, stimulate investigations and monitor progress. In other words, roadmaps are composed of the collective knowledge and the imagination drivers of change in a particular field (Tuominen & Ahlqvist 2010). However, considering roadmapping as a tool for research programme management is new.

Project management is a field of research, which covers a wide range of topics from project evaluation and team building and training to decision making processes and investment appraisals, with the main aim to improve project outcomes. Within the field, relations between projects within a multiple-project environment have been recognised as a major issue for organisation (Payne 1995, Ghomi and Ashjari 2002, Laslo 2010). The research and practice has focused mainly on minimising corporate planning dependent expenses through e.g. project selection, optimisation of research planning and scheduling, and expert hiring to release timetables, without any special interest on forward looking dimension.

Objectives and research questions

In this paper, we propose a future oriented, multi-level approach to R&D programme management. Our approach contributes to the fields of roadmapping and project management alike. Our aim and perspective can be stated through following research questions:

1. What are the foresight methods and tools available to support multi-technological, mission oriented transport research programme planning and management?
2. What are the benefits, difficulties and strategic implications of the foresight driven planning approach?

Material and Methods

In our approach, three types of source materials were used. These included (1) literature review on policy papers, directives, strategies, standards, etc. focal to each programme research theme, (2) interviews and (3) workshop. A working process (Figure 1) was drafted to give structure to the 'desktop work' and to fix the timing of events to involve the relevant people. Firstly, interviews with the key persons of each four TransSmart research themes were scheduled in February and March (4 interviews, 9 interviewees), to be followed by a workshop day in May (16 participants). The workshop gathered the previously interviewed persons together and was further strengthened by those representing public relations, customer management and internal steering group of the TransSmart programme. From May to September, a second round of interviews (6 interviews, 10 interviewees) were carried out to discuss the roadmapping project and its preliminary outcomes with stakeholders from the industry, academia and public administration that were already somewhat familiar with TransSmart programme as members of the external steering group. The complementary research work, carried out as desktop work, included e.g. review of relevant literature and analysis and processing of the results from the interviews and the workshop.

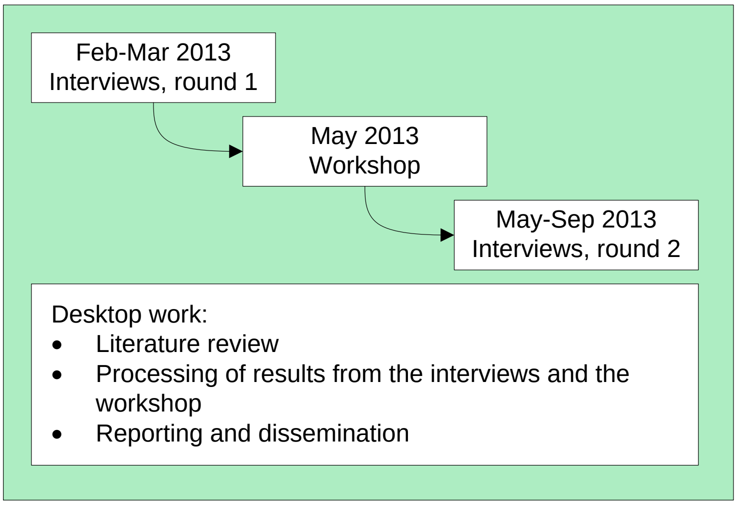

Figure 1. Working process and schedule.

Results

Foresight activities in research programme management

To explore the suitability of foresight methods in transport research programme planning and management, a novel approach for research programme vision building and roadmapping was crafted. Figure 2 shows how the activities of the working process feed into the intended results of the approach. Firstly, the first round interviews provided the basis to deepen the objectives of each of the four TransSmart research themes when theme background, contents, expectations, customers, etc. were discussed. Background research and literature survey was conducted to understand relevant drivers and challenges focal to each theme. The theme-specific outcomes from this phase were vision statements for 2030, driver lists and *transport system illustrations* (Auvinen & Tuominen 2012), presenting the key research areas of each of the research themes.

The first round of interviews prepared the way to combine the four theme-specific visions into a shared vision statement to cover the TransSmart programme as a whole. This vision, and the *system transition roadmap* (Auvinen et al., Manuscript) giving structure to research topics and actions in reaching it, were formulated in the workshop and then discussed in the second round of interviews. The workshop was also the forum where cross-cutting research topics were identified and shaped, using *TAO* (transition, actors and obstacles) approach (Kivisaari et al. 2013). Required transition, relevant actors and obstacles to overcome were identified in parallel to discuss what new competences and business opportunities each topic could presume in short, medium or long term time scale. After the workshop, two roadmaps were drafted for the two furthest developed research topics on the basis of *backpocket roadmap* concept by Ahlqvist (2007).

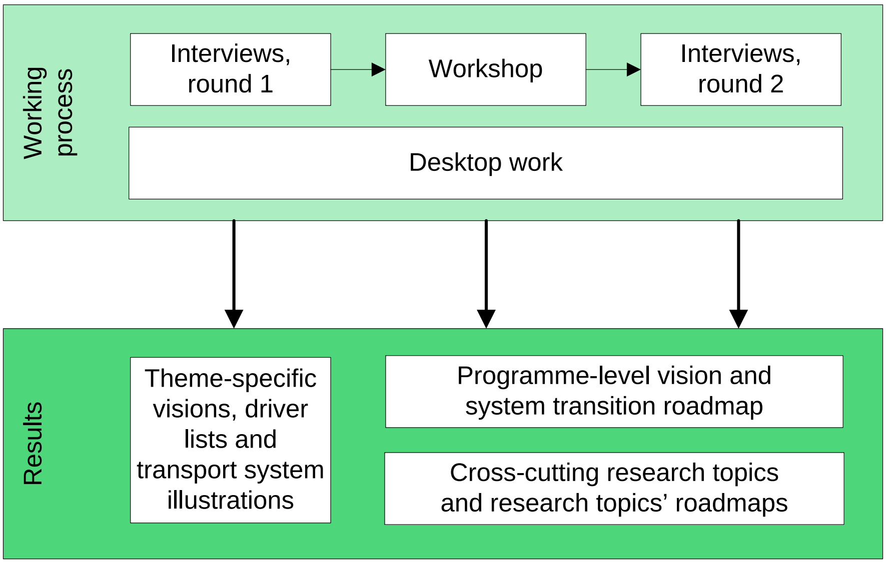

Figure 2. Working process and results.

Vision

In the next paragraph we sum up the vision statement of the TransSmart research programme, entitled *Smart, low-carbon transport system 2030*. The vision presents one plausible future image of the Finnish transport system, describing a preferred view, where the currently pressing societal objectives of the transport policy are addressed, taking into account perspectives of users, service providers and businesses. The vision brings to forefront the topics, where the TransSmart programme contributes through its research, i.e. smart services and products together with sustainable, low-carbon energy for passenger and freight transport.

> *Smart, low-carbon transport system 2030*
>
> The Finnish transport system successfully pursues sustainability in societal, economic as well as environmental terms:
>
> - The transport system is mainly powered by electricity, biofuels and hydrogen. Where conventional fuels and powertrains still apply, the efficiency in using energy and other resources has improved remarkably. Energy systems for transport are well integrated into other infrastructures in terms of production, storage and delivery.
> - Transport and mobility needs of people and goods are fulfilled by a wide range of transport services, characterised by advanced technologies, functionality and efficiency.
> - Development and production of transport fuels, vehicles, mobile machinery, infrastructure and services generate business and profit for the Finnish entrepreneurs in the domestic as well as global markets.
>
> The systematic, continuous work to evolve and adapt the transport system builds on information, knowledge and intelligence from both experts and users. Development, operation and governance are tasks shared in collaboration between the public and private sectors.

Because vision building aims by definition to foster shared understanding and enable mutually aligned action, it was perceived important to revisit the terminology. What was meant by 'low-carbon' and 'smart' in the present context needed to be explained, and short descriptions of these two notions, borne in the very name of the TransSmart programme, were produced:

> **Low-carbon transport system** is fuelled by energy sources that result in as little greenhouse gas emissions as possible, taking into account all phases of the life cycle. Low-carbon energy

covers sustainable production of electricity, biofuels and hydrogen. Aspects of energy efficiency in technological and operational contexts represent a complementary side; advances in combustion engine technologies and support for walking and cycling are also examples of promoting low-carbon transport. Low-carbon energy systems are further characterised by self-sufficiency, renewables and nuclear power.

Smart transport system provides safe high-quality transport and other services in a user-friendly manner that also contributes to the overall fluency in mobility of people and goods. Complex high-end technologies are of secondary importance, and ease of use and functionality are promoted instead. Smart technologies enable customizability and diversity in service offering and take-up of smart solutions is smooth in both public and private sector applications.

The programme-level vision statement was discussed with the representatives of the industry, academia and public authorities in the second round of interviews. The response was in general positive, and the interviewees regarded the vision ambitious, although somewhat unsurprising. The vision was well accepted as a top-level outlook on the focal point of the Finnish transport system, where progress, development efforts and investments are needed in the coming decades. The feedback received from the external interviews was helpful in finalising the wording of the vision statement, and the final outcome was perceived to crystallise the future state of 2030 pursued by the TransSmart programme in a way where national and international transport policy goals meet the ambitions of the transport industries in the extended business ecosystem.

The second round of interviews allowed the external steering group members also to express aspects of critique. One such issue was that the vision remained cautious in fixing any quantitative measures, such as modal split or use of public transport in the target year 2030. Terms such as energy efficiency and automated transport were discussed and suggested as possible inclusions in the scope of the vision. Also, clear intended contributions of the TransSmart programme to support decisions and actions to manage means and modes of transport in the national transport system were requested.

To sum up, the interviewees requested for two divergent missions for the TransSmart programme: (1) long-term societal mission to support large scale transitions in the transport system, (2) short-term techno-commercial mission emphasising national strengths in terms of technologies and knowledge, their business potential and exports. Smart city public transport and building business ecosystems with various stakeholders were research topics highlighted in the interviews.

Roadmap

Figure 3 shows the roadmap for the TransSmart programme, directing actions towards the previously defined TransSmart vision. The graphic view is based on *system transition roadmap* developed by Auvinen et al. (manuscript) that in turn employs the *multi-level perspective (MLP)* approach by Geels (2002). The idea is to combine the three analytical levels to understand transitions in socio-technical systems to three temporal phases. The analytical levels are landscape developments (macro-level), socio-technical regime (meso-level) and technological niches (micro-level) (Geels 2002). The temporal dimension stretches in this case from the present to the envisioned target year 2030, divided into three phases that reflect urgency or temporal potential.

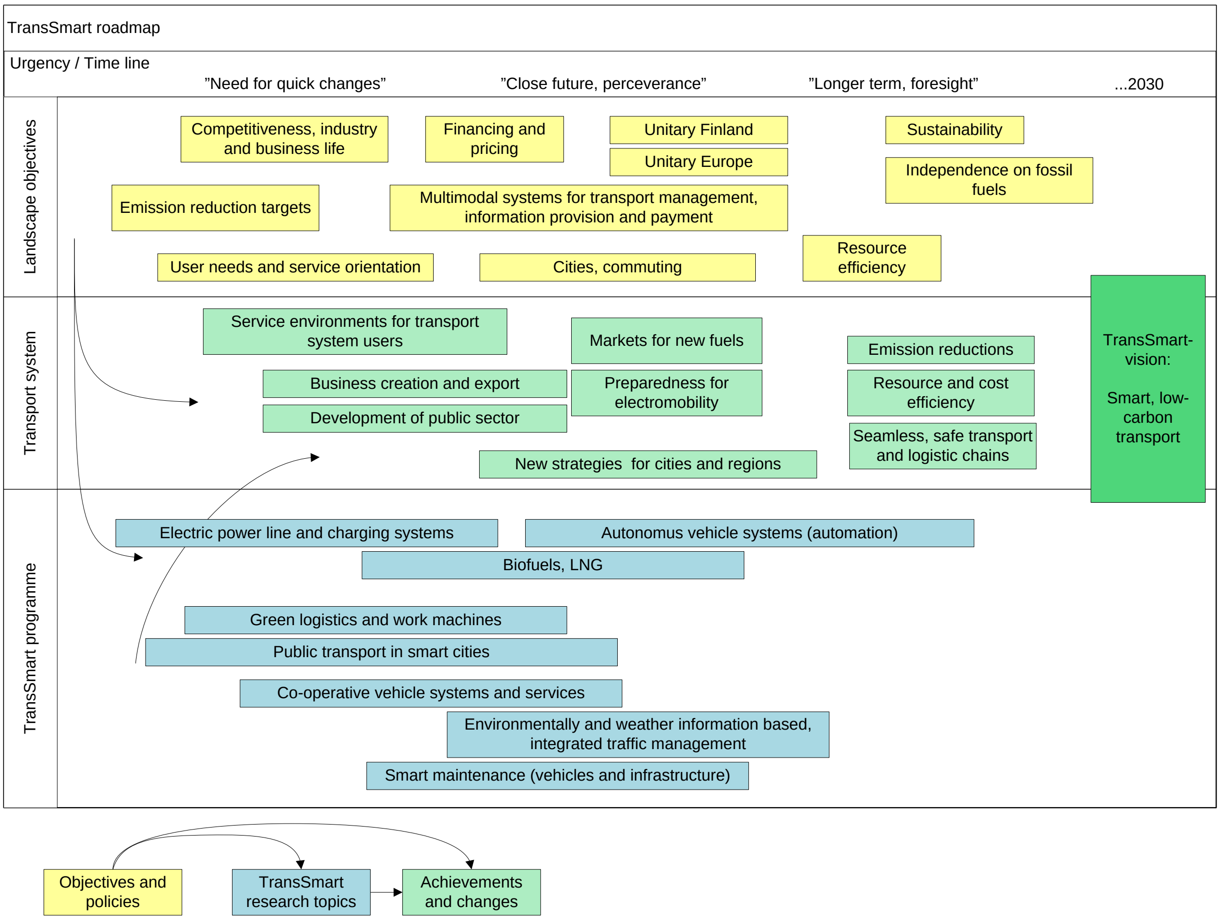

Figure 3. Roadmap for the TransSmart programme.

In our work we fixed the macro-level of the MLP to outline the landscape objectives from transport and energy policies as well as selected mega trends and drivers in the society. These landscape factors influence the transport system that is our choice of study objective on the meso-level. Different types of anticipated new actions and structures (achievements and changes) are mapped on this level, and to promote these achievements towards sustainability in the transport regime, various actions are necessitated. We focus on those related to transport research and show the contributing TransSmart programme key research topics (2013-2016) on the bottom row that represents the micro-level of the MLP.

In combination, the three levels depicted in Figure 3 articulate how the TransSmart research programme serves the landscape objectives and contributes to the development of the smart, low-carbon transport system. The time line reflects the urgency of different research topics with respect to urgency for improving or renewing the currently unsustainable transport system.

Discussion and Conclusions

Our first research question requested for foresight methods and tools available to support multi-technological, mission oriented transport research programme planning and management. In the proposed approach we focus on visioning and roadmapping, which we applied within a multi-level framework of socio-technical change. Our approach presents a novel, forward looking application to the project management in a wider societal context. Common research programme vision, programme system transition roadmap and cross-cutting research topic roadmaps are the main outcomes of the visionary roadmapping process.

In the case of the TransSmart programme, the proposed approach unified separate programme themes, promoted interaction between them and encouraged new cross-cutting research activities. It also brought the needs of the businesses and the society to the fore. Visioning and roadmapping supported the management of this large programme also in terms of dissemination planning by structuring research in ways that facilitates identification of communication channels, cross-cutting (research) topics and target groups. While the approach does not directly address financial aspects of the research programme, the outcomes (foresight knowledge, collaboration between research themes and dialogue with external stakeholders) make an important contribution to strategic decisions on granting research funding and allocation of resources.The second research question sought the benefits, difficulties, and implications of the foresight driven programme planning approach. Visioning and roadmapping for a research programme has various layers of outcomes that support and contribute to not only the work of the programme's research community (the programme itself, the research themes within and the specific research projects and researchers) but also the surrounding stakeholder ecosystem (the public sector, businesses and the national and international research and innovation communities). Foresight contributions and potential benefits span over a long time, and a foresight exercise launched and delivered at the start-phase of the programme may well serve initiation of research as well as the mid-term and ex-poste evaluations of the programme itself. To make use of the visionary roadmappping process and its results, a proactive approach open to discussion is required within the programme management.

As regards the contribution to the research themes and research projects within, the roadmapping process strengthened the awareness of 'the other research themes' and the sense of joint effort that will deepen the impact of the programme later on. It also reduced informational challenges and barriers in preparation of project proposals within the programme's research themes, with external stakeholders and in cross-cutting research topics. Further, the process supports information flow through research projects' life-cycle and across research themes, since e.g. seminars and publications to well-targeted customer segments may be planned as joint efforts.

As the contribution of visioning and roadmapping beyond the research programme, we present the following benefits to strategic planning, businesses and economy. In the TransSmart case, the process crystallised the objectives, drivers and challenges related to the field of the research programme, thus feeding into the broader societal discussions and prioritising and allocation of research funds. Visioning and roadmapping clarified the fragmented research needs of the public sector and the key business stakeholders. The approach may also help to gather the stakeholder ecosystem of a research topic together as one, supporting collaboration, which brings efficiency to identification of new business opportunities and contributes to establishment of research and business consortiums with long-term commitment.

To conclude, the most important contributions of our visioning and roadmapping exercise can be found in the interaction the approach initiated between the different programme stakeholders. First, and most importantly, a common view (vision 2030) on future developments and actions was received among the programme stakeholders. We realised that the research-programme level vision should address the national domain in the sense that different stakeholders are able to relate to it. Also orientation to previous research as well as other on-going efforts in the sector is important. Second, the process clarified and matured the individual programme theme contents. Third, the roadmapping process helped the stakeholders to place the programme into a wider societal frame that increased their commitment and acceptance for the programme. Finally, information sharing and project co-operation may serve as a mutual learning process, which further enhances knowledge creation and management practices in stakeholder organisations. Here, programme leader has the very important role of proactive bridge building and coordination.

In the future, the proposed visioning and roadmapping process could serve as a starting point and learning environment also for other similar efforts, where roles of sub-entities of a large (e.g. research or innovation) programme need to be crystallised and aligned with respect to one another. Mutual commitment to a shared vision and roadmap and interaction with external stakeholders from the academia, industry and public authorities brings further affirmation to the programme-level objectives and causes and hence promotes the societal embedding of the programme and clarifies the allocation of often scarce resources

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Proposed Electricity Generation Plan for Jamaica

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Up until 1995, the Jamaica Public Service Company (JPSCo) held a monopoly on the generation, transmission and distribution of electricity in Jamaica. In 1995, the generation regime was liberalized to include generation of electricity by private producers for their own use or for sale to the national grid. Currently, JPSCo accounts for only 69% of the generation capacity. The remaining 31% of the power is generated by Independent Power Producers (IPP) under the Independent Power Purchase Agreements (National Energy Policy 2009, Ministry of Energy and Mining).

The JPSCo has a total installed capacity of 611.5MW and a net generating capacity of 549.3 MW using Automotive Diesel Oil and Heavy Fuel Oil. The company also has installed a total of 22.8 MW of hydro power and 3MW of wind power. The IPP have a total installed capacity of 260.9 MW and a net generating capacity of 250.3 MW also using Automotive Diesel Oil and Heavy Fuel Oil and 38.7 MW of wind power.

Net Generation in 2013 was 4,725 GWh and it is expected to grow at an average rate of 4.0% for the next twenty (20) years. Also the Net System Peak demand in 2012 was 686.5 MW, this is also projected to grow at an average rate of 3.8% for the next twenty (20) years.

The average age of the generating units owned by the JPSCo is 37.3 years old. These units are characterized by low thermal efficiencies. As a result of these and other issues, Jamaica currently has one of the highest costs of energy in the region.

The proposed expansion plan seeks to replace old and inefficient plants, lower the cost of energy in Jamaica, diversify the fuel option and guarantee energy security. Two options were proposed in the expansion plan, Option 1 adhere strictly to the fuel matrix outlined in the National Energy Policy. While Option 2 take into account the limitation of resources existing in the country.

Option 1, recommends the addition of 312 MW of capacity in 2015 to replace 291.7 MW of dated capacity the same year. The new capacity will include 140 MW Natural Gas Combine Cycle, 120 MW Slow Speed Diesel and 52 MW of renewable capacity. Overall Option 1 recommends the addition of 1,275 MW of new capacity up to 2030.

Option 2, recommends the addition of 230 MW of capacity in 2015 to replace 270.3 MW of dated capacity the same year. The new capacity will include a 140 MW Natural Gas Combine Cycle, 40 MW Coal/Petcoke and 50 MW of renewable capacity. Overall Option 2 recommends the addition of 1,300 MW of new capacity up to 2030. Both options would guarantee adequate reserve capacity.

Introduction

Energy is one of the essential needs of a functioning society. The scale of its use is closely associated with its capabilities and the quality of life that its members experience. Worldwide, great disparities are evident among nations in their level of energy use, prosperity, health, political power and demand on the world's resources.

The pattern of energy used worldwide reflects the distribution of wealth among nations. Of the earth's approximately seven billion people, roughly 20% live in wealthy, industrialized countries of Western Europe, North America and Japan. Another twenty percent live within rapidly industrializing societies such as South Korea, Taiwan, China, South Africa, Thailand and Brazil. They account for much of the growth in energy demand. The rest of the world is largely primitive economically and is developing slowly, although many countries in this region have wealthy elite, small region of prosperity and more rapid development (Tester et al., 2005).

Growth in energy demand reflects the pace of economic development. Industrialized countries account for most of the consumption of energy worldwide and because of its wealth is the group most able to protect the environment from degradation as a consequence of the energy consumption. The United States has a specific energy consumption of 350 million Btu/capita. The Caribbean region with nearly 9% of the world population, accounts for only 6% of global energy consumption and a specific energy consumption of about 60 million Btu/capita (Tester et al., 2005). With some variation between countries and sectors, the demand for energy in the region has risen steadily in recent years driven by population growth and economic development.

Background

In recent years, the use of fossil fuel for industrial application and for the production of electricity in the region has increased. As a result, oil and its by-products accounts for over 40% of total energy supply in the region followed by natural gas which account for 25%. However, some countries in the region are constructing the necessary infrastructure to support the use of natural gas for power generation.

In Jamaica, oil and oil products represent more than 90% of the energy consumed. Therefore, to guarantee energy security the Government of Jamaica has developed the Jamaica's National Energy Policy 2009–2030 to ensure that by 2030 Jamaica achieves a modern, efficient, diversified and environmentally sustainable energy sector. One that provides affordable and accessible energy supplies with long term energy security; and supported by informed public behaviors on energy issues and an appropriate policy, regulatory and institutional framework, (The Jamaica's National Energy Policy 2009–2030, 2009). This Strategic Framework also addresses both supply and demand energy issues faced by the country and as such places priority attention on seven key areas:

1. Security of energy supply through diversification of fuels as well as development of renewable.
2. Modernizing the country's energy infrastructure
3. Development of renewable energy sources such as solar and hydro
4. Energy conservation and efficiency
5. Development of a comprehensive governance/regulatory framework
6. Enabling government ministries, departments and agencies to be model/leaders for the rest of society in terms of energy management
7. Eco-efficiencies in industries

By focusing on the seven priority areas listed above, the National Energy Policy will ensure that the country minimizes the effects of volatile and rising crude oil prices, take advantage of renewable resources and promotes conservation and efficiency in the use of energy resources among all sectors of society. The ultimate outcome of achieving the seven goals of this policy will be the provision of more affordable energy supply to Jamaican consumers, and improve competitive base for the country; as well as sustainable growth and development of the nation, (The Jamaica's National Energy Policy 2009–2030, 2009).

It is a fact that the energy matrix in Jamaica comprises 93% on Petroleum and 7% Renewable energy in 2013. However, Jamaica has embarked on strategies that will see the reduction of the dependence on petroleum in the energy matrix to 52% Petroleum by 2020 and 30% by 2030. Natural Gas will increase to 26%, Renewables to 15%, Petcoke/coal to 5% and others sources to 5% by 2020. However, by 2030 the contribution of non-petroleum sources will continue to increase, Natural Gas to 42%, Renewables to 20%, Petcoke/coal will remain at 5% and others about 3%. This would mean that after 2020, no single fuel source will constitute more that 50% towards electricity generation.

In order to achieve this, large energy infrastructure projects must be developed. Firstly, it will be essential to secure the necessary funding for expansion of generation infrastructure required for cleaner, more efficient and secure alternatives. Secondly, a secure supply of non-traditional sources of energy should be guaranteed. Due to these and other constrains, government should stay clear of funding these projects, however, they should create the climate governed by policies to attract private investments.

Electricity Sector in Jamaica

The Jamaica Public Service Company (JPSCo.) the sole energy provider in Jamaica provides electricity services to about 580,000 customers. The JPSCo started out as a private company, owned by foreign shareholders. In 1970, the Government of Jamaica (GoJ) acquired controlling interest in the company. In 2001 the GoJ sold 80% of the company to Mirant Corporation, a US based energy service provider while retaining almost 20%. The remanding amount which is less than 1% was owned by a shareholder group (Binger 2011). In 2007, Mirant sold its majority shares to Marubeni Caribbean Power Holding (MCPH) Inc., a subsidiary of Marubeni Corporation of Japan. In early 2009, Abu Dhabi National Energy Company (TAQA) of the United Arab Emirates joined Marubeni as co-owner of the JPSCo majority shares under the name Marubeni TAQA Caribbean.

Up until 1995, JPSCo. held a monopoly on the generation, transmission and distribution of electricity to its customers. In 1995, the generation regime was liberalized to include generation of electricity by private producers for their own use or for sale to the national grid. Currently, JPSCo accounts for only 68% of the generation capacity. The remaining 32% of the power is generated by Independent Power Producers (IPP) under the Independent Power Purchase Agreements (National Energy Policy 2009, Ministry of Energy and Mining).

Table 1 details the four oil based generating plants owned and operated by JPSCo. The plants are located in Bogue in St James, Old Harbour Bay in St Catherine, Hunts Bay, and Rockfort in Kingston. The total installed capacity of the four plants is 611.5 MW with a net generating capacity of 549.3MW.

Table 1. Oil based Generating Plants owned and operated by JPSCo.

Name of Plant/Unit	Gross Capacity (MW)	Net Capacity (MW)	Plant Type	Fuel Type	Age
Unit #3 Bogue	21.5	21.4	Open Cycle Gas Turbine	ADO	40
Unit # 6 Bogue	18.0	17.9	Open Cycle Gas Turbine	ADO	23
Unit # 7	18.0	17.9	Open Cycle Gas Turbine	ADO	23
Unit #8	14.0	Out of Service	Open Cycle Gas Turbine	ADO	21
Unit #9	20.0	19.9	Open Cycle Gas Turbine	ADO	21
Unit #11	20.0	19.9	Open Cycle Gas Turbine	ADO	12
Combine Cycle, Bogue	114.0	111.0	Combine Cycle Gas Turbine	ADO	10
Unit # 5 Hunts Bay	21.5	21.4	Open Cycle Gas Turbine	ADO	39
Unit # 10 Hunts Bay	32.5	32.1	Open Cycle Gas Turbine	ADO	20
Unit # 6 Hunts Bay	68.5	64.4	Steam Turbine	HFO[2]	37
Unit # 1 Old Harbour	30.0	Out of Service	Steam Turbine	HFO	45
Unit # 2 Old Harbour	60.0	57.4	Steam Turbine	HFO	43
Unit # 3 Old Harbour	65.0	62.5	Steam Turbine	HFO	41
Unit # 4 Old Harbour	68.5	64.6	Steam Turbine	HFO	40
Unit # 1 Rockfort	20.0	19.5	Reciprocating Engine	HFO	28
Unit # 2 Rockfort	20.0	19.4	Reciprocating Engine	HFO	28
Total	**611.5**	**549.3**			

In addition, JPSCo operates ten renewable energy sites (Table 2), with a total generating capacity of 32.3 MW (29.3 MW hydro and 3 MW of wind). The sites consist of nine small hydro turbines located on the North and South Coasts and a wind farm, located on the South Coast of Jamaica. The wind farm was commissioned in 2010 and operates four wind turbines and has a total installed output of 3.0 MW. It is the first wind farm to be owned by JPSCo and is located in Munro, St Elizabeth. Installation of Hydro Plants in Jamaica dates back to 1910 when the first turbine was installed at Rams Horn. Currently this plant has out live it operational life and has been taken out of service.

Table 2. Renewable Energy Generating Plants owned and operated by JPSCo

Name of Plant/Unit	Gross Capacity (MW)	Net Capacity (MW)	Plant Type	Fuel Type	Age (year)
JPS Munro (Wind Farm)	3.0	3.0	Wind Turbine	Wind	3
Constant Spring (Hydro)	0.8	0.8	Hydro Turbine	Water	25
Lower White River (Hydro)	4.7	4.7	Hydro Turbine	Water	61
Upper White River (Hydro)	3.6	3.6	Hydro Turbine	Water	70
Maggoty (Hydro) A	6.0	6.0	Hydro Turbine	Water	54
Maggoty (Hydro) B	6.5	6.3	Hydro Turbine	Water	0.25
Rams Horn (Hydro)	-	-	Hydro Turbine	Water	103
Rio Bueno A (Hydro)	2.5	2.5	Hydro Turbine	Water	58
Rio Bueno B (Hydro)	1.1	1.1	Hydro Turbine	Water	25
Roaring River (Hydro)	4.1	4.1	Hydro Turbine	Water	63
Total	**32.3**	**32.1**			

Since the early 1990s, JPSCo has invited Independent Power Producers to generate and sell power to the national grid under a Power Purchase Agreement (PPA). This was done to liberalize the energy market and stimulate competition thus providing cheaper power to the Jamaican consumers. Since 1995 when the first Independent Power Producer (IPP) was commissioned and started to supply electricity, there has been a number of IPPs entering and leaving the market. Currently, only four IPPs remain, the Jamaica Energy Partners (JEP), Jamaica Private Power Company (JPPC), JAMALCO and Wigton Windfarm Limited, generating a total of 289 MW (Table 3), which is about 32% of the total installed capacity in Jamaica.

JEP was the first to start supplying electricity to the Jamaican power grid since 1995, as a result of an agreement with the JPSCo. JEP operates two power barges, namely Doctor Birds I and II, with combined generating capacity of approximately 124.4 MW; this is approximately fifteen percent (15%) of Jamaica's installed capacity. The most recent addition was a 65 MW West Kingston Power Partner (WKPP) Power Plant. All three plants operate Wärtsilä medium speed diesel generating sets using heavy fuel oil. With the addition of WKPP, the total generating capacity of JEP has been increased to approximately 189.4 MW making it one of the major suppliers of electricity in Jamaica.

JPPC owns a base-load 60 MW heavy fuel oil-fired generating facility located on the eastern side of Kingston, Jamaica. The plant consists of two MAN B&W 9K80MC-5 diesel powered generators. The plant commenced operations on January 6, 1996. As of October 30, 2007, JPPC operated as a subsidiary of AEI.

The Jamalco Alumina Refinery was commissioned in 1972 as part of the refinery’s operation. This integral powerhouse consists of medium pressure boilers and back pressure turbines to provide the refinery’s process heating and power requirements. Steam-power balance is achieved by minor import or export of electric power to the national grid.

Wigton Windfarm Limited owns and operates wind farms in Jamaica to harness wind energy for commercial production and to generate electricity for sale to customers in Jamaica under a similar PPA. The company was incorporated in 2000 and is headquartered in Kingston, Jamaica. Wigton Windfarm Limited operates as a subsidiary of Petroleum Corporation of Jamaica.

Currently, Wigton Windfarm Limited operates two wind farms, namely Wigton I and Wigton II with combined capacity of 38.7 (20.7 and 18) MW; this is approximately 4% of Jamaica's installed capacity. The first wind farm, Wigton I, supplies 20.7 MW from twenty three 0.9 MW NEG-Micron 900/52 wind turbines. The second wind farm was commissioned in 2004. Wigton II supplies 18 MW from nine (9), 2 MW Vestas V80 wind turbines. The current fuel matrix in Jamaica is outlined in Table 4.

Table 3. Oil based generating Plants owned and operated by Independent Power Producers

Name of Plant/Unit	Gross Capacity (MW)	Net Capacity (MW)	Plant Type	Fuel Type	Age
Jamaica Energy Partners (JEP)- Barge 1	124.4	124.4	Reciprocating Engine	HFO	18
Jamaica Energy Partners (JEP)- Barge 2			Reciprocating Engine	HFO	7
(JEP) West Kingston Power Plant	65.5	65.5	Reciprocating Engine	HFO	1
Jamaica Private Power Company (JPPC)	60.0	60.0	Reciprocating Engine	HFO	17
JAMALCO	11.0	0.4	Steam Turbine	HFO	13
Total	**260.9**	**250.3**			
Renewable					
Wigton I (Wind Farm)	20.7	20.7	Wind Turbine	Wind	9
Wigton II (Wind Farm)	18.0	18.0	Wind Turbine	Wind	2
Total	**38.7**	**38.7**			

Demand Forecast

The Government of Jamaica (GoJ) in its Energy Policy (The Jamaica's National Energy Policy 2009–2030, 2009) indicated that the growth in energy demand is directly related to the GDP. The forecasting of electricity demand is based on the factors that would influence the electricity demands. These factors can be split into four (4) broad areas:

- Economic activities (measured by GDP)
- demographics
- electricity prices and demand responsiveness
- energy intensities (type of electricity end use and technology)

(Office of Utilities Regulation, "Generation Expansion Plan 2010", 2010).

Table 4. Current Fuel Matrix in Jamaica.

<table>
<tr><th>Fuel Type</th><th>Plant Type</th><th>Number of Plants</th><th>Total Installed Capacity (MW)</th><th>% of Total</th></tr>
<tr><td rowspan="3">HFO</td><td>Steam (Power Only)</td><td>5</td><td>292</td><td rowspan="5">92.5</td></tr>
<tr><td>Steam (CHP)</td><td>1</td><td>11</td></tr>
<tr><td>Reciprocating Engines</td><td>6</td><td>289.5</td></tr>
<tr><td rowspan="2">ADO</td><td>Combine Cycle</td><td>1</td><td>114</td></tr>
<tr><td>Combustion Turbine</td><td>8</td><td>165.5</td></tr>
<tr><td>Total Petroleum Fuel</td><td></td><td></td><td>872.0</td><td></td></tr>
<tr><td>Wind</td><td>Wind Farm (Renewable Energy)</td><td>3</td><td>41.7</td><td rowspan="2">7.5</td></tr>
<tr><td>Hydro</td><td>Hydro Plant (Renewable Energy)</td><td>8</td><td>29.3</td></tr>
<tr><td>Total Renewable Energy</td><td></td><td></td><td>71.0</td><td></td></tr>
<tr><td>Total</td><td></td><td></td><td>943.0</td><td>100</td></tr>
</table>

These drivers can change overnight in response to external factors that were not considered in the forecasting. As a result the OUR did a base, low and high projection to compensate for external factors that were not considered.

Table 5 show the base demand projection for electricity from 2013 to 2029, put forward by the OUR ("Generation Expansion Plan 2010", 2010). The forecast demand for electricity is based primarily on the Government's official projection for the country's economic growth. The economic indicators are mainly provided by the Planning Institute of Jamaica (PIOJ). From the table it can be seen that the Net Generation in 2012 was 4,531 GWh and it is expected to grow at an average rate of 4.0% for the next twenty (20) years. Also the Net System Peak demand in 2012 is 660.8 MW, this is also projected to grow at an average rate of 3.8% for the next 20 years.

Table 5. Base ForecastNet Generation and Net System Peak (2010–2029) proposed by the OUR.

Years	Net Gen (MWh)	Net Gen Growth Rate (%)	Load Factor (%)	Net System Peak (MW)	Peak Growth Rate (%)
2012	4,531,735	3.61	78.28	660.8	3.17
2013	4,725,330	4.27	78.57	686.5	3.89
2014	4,951,437	4.78	78.84	717.0	4.44
2015	5,190,379	4.83	79.07	749.3	4.50
2016	5,434,953	4.71	79.28	782.6	4.44
2017	5,681,720	4.54	79.47	816.1	4.28
2018	5,949,989	4.72	79.64	852.8	4.50
2019	6,223,245	4.59	79.8	890.3	4.40
2020	6,502,098	4.48	79.93	928.6	4.30
2021	6,786,213	4.37	80.06	967.7	4.21
2022	7075842	4.27	80.17	1,007.6	4.12
2023	7,370,946	4.17	80.27	1,048.3	4.04
2024	7,671,693	4.08	80.35	1,089.9	3.97
2025	7,978,175	3.99	80.43	1,132.3	3.89
2026	8,290,569	3.92	80.51	1,175.6	3.82
2027	8,609,043	3.84	80.57	1,219.8	3.76
2028	8,933,808	3.77	80.63	1,264.9	3.70
2029	9,265,086	3.71	80.68	1,310.9	3.64

Source: Office of Utilities Regulation, "Generation Expansion Plan 2010", 2010

At the start of 2014 the Base Generation and Load Forecast data for Jamaica was reviewed and it was discovered that the forecast put forward in 2010 by the OUR overestimated the load demand. Table 6 is a more realistic forecast which was extrapolated from actual data received from the JPSCo. Here again the drivers can change overnight in response to external factors that were not considered in the forecasting.

Demand Projection

In 2013 the gross installed capacity was 936.9MW, with a net installed capacity of 864.1MW and a firm installed capacity of 828.9MW but the system peak was 586.5MW giving a total reserve capacity in excess of 41%, for example the reserve capacity in 2013 was 347.9 MW or 61% while in 2030 the reserve capacity is projected to be 356.9 MW which is 41.3%. The reserve capacity would allow for the removal of more than 150 MW without adversely affecting the service provided to the consumers.

Table 6. Base Generation and Load Forecast developed by JPSCo – Net Generation and Net System Peak (2012–2030)

Years	Net Gen (MWh)	Net Gen Growth Rate (%)	Load Factor (%)	Net System Peak (MW)	Peak Growth Rate (%)
2012	4,135,918	3.61	78.58	600.80	3.17
2013	4,141,643	0.138	80.6	586.50	2.38
2014	4,177,144	0.857	81.1	588.10	0.27
2015	4,255,451	1.87	81.0	600.10	2.04
2016	4,341,662	2.025	81.3	609.0	1.48
2017	4,412,865	1.64	81.3	619.40	1.70
2018	4,519,948	2.42	81.4	633.30	2.24
2019	4,587,747	1.5	81.07	645.97	2.0
2020	4,656,563	1.5	80.6	658.90	2.0
2021	4,749,694	2.0	80.02	675.35	2.5
2022	4,844,688	2.0	79.9	692.24	2.5
2023	4,941,582	2.0	79.5	709.54	2.5
2024	5,040,414	2.0	79.11	727.28	2.5
2025	5,141,222	2.0	78.73	745.46	2.5
2026	5,269,752	2.5	78.3	767.83	3.0
2027	5,401,496	2.5	77.96	790.86	3.0
2028	5,536,534	2.5	77.5	814.59	3.0
2029	5,674,947	2.5	77.2	839.03	3.0
2030	5,816,821	2.5	76.83	864.20	3.0

Source: Jamaica Public Service Company Limited (2013)

The expansion plan also considers that thermal plants will have a productive life expectancy of 35 years, hydro plants 90 years and wind turbines 20 years. Therefore, thermal plants 35 years and older in 2013 will be retired in 2016 when the 381 MW Natural Gas plant is to be commissioned.

Generation Expansion Plan

Various power plant types are available for the expansion of the electricity generation system, such as combined and simple cycle gas turbines, internal combustion reciprocating engines, pulverized coal plants, nuclear plants, hydropower plants, wind turbines and photovoltaic. The selection of the most suitable types of power plant for the power generation mix is based to a large extent on their specific operational performance and cost characteristics. However, this demand projection shown in Table 8 and graphically in Figure 1 was fashioned based on the Energy Matrix 2012 to 2030, (Table 7), put forward by the MSTEM.

Table 7. Energy Matrix.

Fuel Type	2016		2020		2025		2030	
	%	MW	%	MW	%	MW	%	MW
Petroleum	67	647.1	52.0	528.3	41	452.0	30.0	366.3
Natural Gas	15	144.9	26.0	264.1	34	374.8	42.0	512.9
Coal / Petcoke	5	43.3	5.0	50.8	5	55.1	5.0	61.1
Renewable	12.5	120.7	15.0	152.4	17.5	192.9	20.0	244.2
Other	0.5	4.8	2.0	20.3	2.5	27.6	3.0	36.6
Total	100	965.9	100	1,015.9	100	1,102.3	100	1,221.3

Ministry of Energy and Mining, Jamaica's National Energy Policy 2009-2030, October 2009

Table 8. Demand Projection from 2013 to 2030.

Year	System Peak (MW)	Gross Replacement Capacity (MW)	Annual Increase and Replacement (MW)	Installed Capacity (MW)	Percent Reserve Capacity	Planned Installation (MW)
2013	586.5	-	-	943.4	60.8	
2014	588.1	305.0 delayed until 2016	-	943.4	60.4	
2015	600.1	-	-	943.4	57.2	
2016	609.0	305.0	327.5	965.9	58.6	71.0 + 381.0
2017	619.4	-	-	965.9	55.9	
2018	633.3	-	-	965.9	51.1	
2019	646.0	-	-	965.9	49.5	
2020	659.0	40.0	90.0	1,015.9	54.1	
2021	675.35	-	-	1,015.9	50.4	
2022	692.24	-	-	1,015.9	46.7	
2023	709.54	-	-	1,015.9	43.1	
2024	727.28	20.7	89.0	1,084.2	49.07	
2025	745.46	36.0	54.2	1,102.3	47.8	
2026	767.83	-		1,102.3	43.5	
2027	790.86	20.0	65.4	1,147.7	45.1	
2028	814.59	32.5	56.2	1,171.5	43.8	
2029	839.03	-		1,171.5	39.6	
2030	864.20	77.0	126.6	1,221.1	41.2	

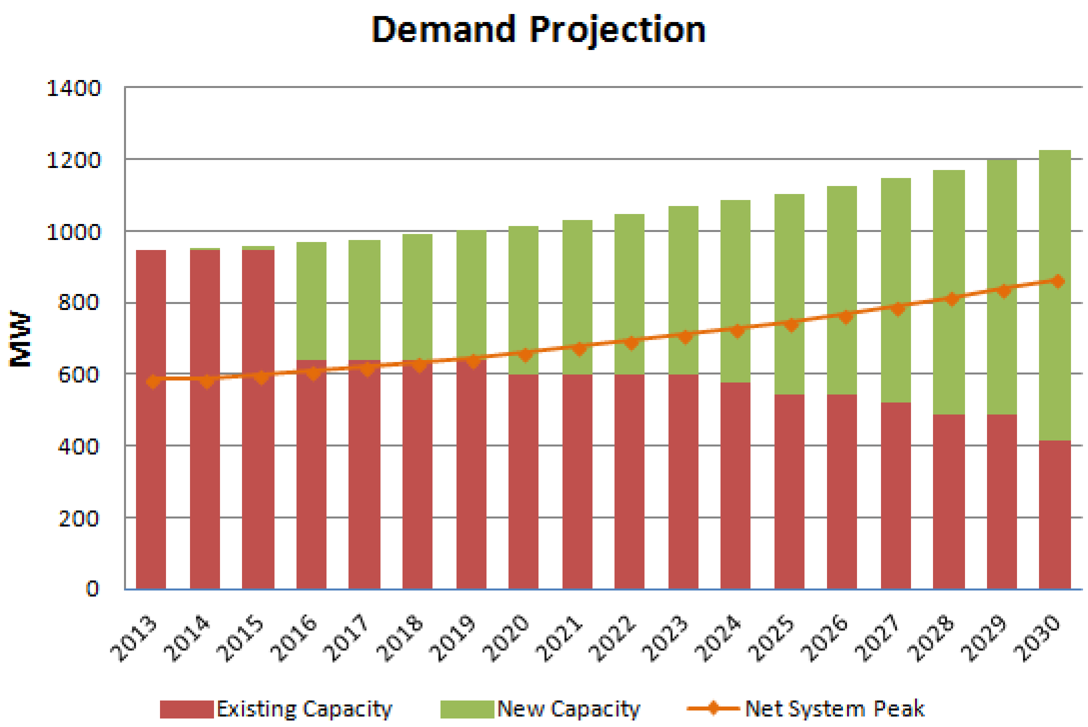

Figure 1. Demand Capacity requirement up to 2030 based on Energy Matrix,

Expansion Options

Two options are proposed, Option 1 was developed to fulfil the energy matrix as outlined by MSTEM in the Energy Policy (The Jamaica's National Energy Policy 2009–2030, 2009). Option 2 is based on a 381MW, Natural Gas combine cycle plant slated to start operating in 2016. Option 2 also considers the renewable resource limitation in the country. For example, the renewable energy contribution in 2030 will be in excess of 313 MW based on the National Energy Policy. However, the total hydro power potential in Jamaica is limited to 94 MW while the total wind energy potential is still under investigation. The annual contribution from solar is unknown, but currently about 1 MW is produced by solar thermal and another 1MW is produced by distributed solar photovoltaic.

Option 1

This plan was fashioned based on the Energy Matrix 2012 to 2030, put forward by the MSTEM. The Energy Matrix based on Option 1 is presented in Table 9. The recommended expansion plan is as follows:

2016:

- Commissioning of 102.0 MW (3 x 51MW) Slow Speed Diesel Capacity
- Commissioning of 51.0 MW Natural Gas fired Open Cycle Capacity
- Commissioning of 145.0 MW Natural Gas fired Combine Cycle Capacity
- Commissioning of 50 MW Coal Unit Capacity
- Commissioning of 25.8 MW (3 x 6.0 MW and 2 x 3.9 MW) Hydro Turbines
- Commissioning of 26.0 MW (13 x 2.0 MW Vestas V80 Wind Turbine) Wind Farm
- Commissioning of 500 kW Solar Photovoltaic Installation

- Displacement of a total of 43.0 MW of Open Cycle Gas Turbines Capacity (Bogue Unit #3 and Hunts Bay Unit #5)
- Displacement of a total of 262.0 MW of Steam Capacity (Hunts Bay Unit #6, Old Harbour Units #2, #3 and #4)

2020:

- Commissioning of 26 MW (13 x 2MW Vestas V80 Wind Turbine) Wind Farm
- Commissioning of 119.2 MW Natural Gas fired Combine Cycle Capacity
- Commissioning of 5.7 MW (1 x 5.7 MW) Hydro Turbines
- Displacement of a total of 40 MW of Low Speed Diesel (Rockfort Unit #1 and #2)

2024:

- Displacement of a total of 20.7 MW of Renewable Wind (Wigton I)

2025:

- Commissioning of 110.7 MW Natural Gas fired Combine Cycle Capacity
- Commissioning of 40 MW (20 x 2MW Vestas V80 Wind Turbine) Wind Farm
- Commissioning of 20.2 MW (2 x 6.0 MW and 2 x 4.1 MW) Hydro Turbines
- Commissioning of 1 MW Solar Photovoltaic Installation
- Displacement of a total of 36.0 MW of Open Cycle Gas Turbines Capacity (Bogue Unit #6 and #7)

2027:

- Displacement of a total of 20.0 MW of Open Cycle Gas Turbines Capacity (Bogue Unit #9)

2028:

- Displacement of a total of 32.5 MW of Open Cycle Gas Turbines Capacity (Hunts Bay Unit #10)

2030:

- Commissioning of 138.1 MW Natural Gas fired Combine Cycle Capacity
- Commissioning of 45 MW (15 x 3MW Vestas Wind Turbine) Wind Farm
- Commissioning of 9.3 MW (2 x 4.65 MW) Hydro Turbines
- Displacement of a total of 74.0 MW of Medium Speed Diesel Capacity (Doctor Bird I)
- Displacement of a total of 3.0 MW of Wind Capacity (Munro)

Table 9. Energy Matrix based on Option 1

Fuel Type	2016		2020		2025		2030	
	%	MW	%	MW	%	MW	%	MW
Petroleum	67	647.1	55.45	607.1	43.1	492.3	30.66	378.0
Natural Gas	15	144.9	24.14	264.1	32.79	374.8	41.61	512.9
Coal / Petcoke	5	48.3	4.64	50.8	4.82	55.1	4.95	61.1
Renewable	12.5	120.7	13.92	152.4	16.88	192.9	19.81	244.2
Other	0.5	4.8	1.85	20.3	2.41	27.6	2.97	36.6
Total	100	965.8	100	1,094.7	100	1,142.7	100	1,232.8

Option 2

This plan was fashioned based on the current projects put out to tendered by the OUR such as 71 MW Renewable Energy and 381 MW Natural Gas Projects. The Energy Matrix based on Option 2 is presented in Table 10. The recommended expansion plan is as follows:

2016:

- Commissioning of 381 MW Natural Gas fired Combine Cycle Capacity
- Commissioning of 20 MW Open Cycle Gas Turbines Capacity
- Commissioning of 40 MW (20 x 2MW Vestas V80 Wind Turbine) Wind Farm
- Commissioning of 30 MW (5 x 6.0 MW) Hydro Turbines
- Commissioning of 1 MW solar photovoltaic installation
- Displacement of a total of 43.0 MW of Open Cycle Gas Turbines Capacity (Bogue Unit #3 and Hunts Bay Unit #5)
- Displacement of a total of 262.0 MW of Steam Capacity (Hunts Bay Unit #6, Old Harbour Units #2, #3 and #4)

2020:

- Commissioning of 53.7 MW (1 x 53.7 MW) Slow Speed Diesel Capacity
- Commissioning of 10.4 MW (2 x 5.2 MW) Hydro Turbines
- Displacement of a total of 40 MW of Low Speed Diesel (Rockfort Unit #1 and #2)

2024:

- Commissioning of 22 MW (11 x 2MW Vestas V80 Wind Turbine) Wind Farm
- Displacement of a total of 20.7 MW of Renewable Wind (Wigton I)

2025:

- Commissioning of 11.2 MW (2 x 5.6 MW) Hydro Turbines
- Commissioning of 28.0 MW (14 x 2MW Vestas V80 Wind Turbine) Wind Farm
- Commissioning of 61.1 MW Coal Unit Capacity
- Displacement of a total of 36.0 MW of Open Cycle Gas Turbines Capacity (Bogue Unit #6 and #7)

2027:

- Displacement of a total of 20.0 MW of Open Cycle Gas Turbines Capacity (Bogue Unit #9)

2028:

- Displacement of a total of 32.5 MW of Open Cycle Gas Turbines Capacity (Hunts Bay Unit #10)

2030:

- Commissioning of 40 MW Coal Unit Capacity
- Commissioning of a 131.9 MW Natural Gas Combined Cycle Turbine
- Commissioning of 60 MW (20 x 3MW Vestas V80 Wind Turbine) Wind Farm
- Commissioning of 34.8 MW (6 x 5.8 MW) Hydro Turbines
- Displacement of a total of 74.0 MW of Medium Speed Diesel Capacity (Doctor Bird I)
- Displacement of a total of 3.0 MW of Wind Capacity (Munro)

Table 4. Energy Matrix based on Option 2.

Fuel Type	2016		2020		2025		2030	
	%	MW	%	MW	%	MW	%	MW
Petroleum	49.6	514.6	49.76	528.3	43.67	492.3	33.54	418.3
Natural Gas	36.72	381.0	35.88	381.0	33.8	381.0	41.12	512.9
Coal / Petcoke	0.0	0.0	0.0	0.0	5.42	61.1	4.9	61.1
Renewable	13.68	142.0	14.36	152.4	17.11	192.9	19.58	244.2
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.86	10.7
Total	100	1037.6	100	1,061.7	100	1,127.3	100	1,247.2

Conclusion

From the analysis conducted and described above the following conclusions can be made:

- Net Generation in 2013 was 4,141GWh and it is expected to grow at an average rate of 2.0% for the next seventeen (17) years. Also the Net System Peak demand in 2013 was 586.50MW, this is also projected to grow at an average rate of 2.3% for the next seventeen (17) years.
- The average age of the current stock of generating units owned by JPSCo is 37.4 years old. They are also energy inefficient and rely heavily on expensive Automotive Diesel Oil and Heavy Fuel Oil. Therefore, new base load capacity is urgently needed to replace the old units, provide energy security and reduce the cost of energy to the consumers.
- The current study recommends two options for the expansion plan; Option 1, recommends the addition of 298.3 MW of capacity in 2016 to replace of 305.0 MW of dated capacity the same year.

Option 2, recommends the addition of 472 MW of capacity in 2016to replace 305 MW of dated capacity the same year.

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Human Mobility in the Context of Sustainable Energy Services in Brazil

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Human mobility in the context of sustainable energy services in Southern American countries has received great attention from various global actors. In Brazil, for example, many projects, programs, and studies have already been taken to find peoples social positions in structural energy services. It has, however, become evident that human mobility research, which has both socio-economic and sociocultural impact of ensuring sustainable energy services, has not durably received comprehensive treatment by the previous research. Drawing largely from data qualitatively collected via observation, focus group discussions, semi-structured interviews from thirty five people of Sao Paulo state of Brazil. This paper examines how existing energy systems have been constructed in Brazil. The results show that non-ethics and politically exploitative energy services cause uncontrolled human mobilization resulting in very high urban unemployment. This paper provides theoretical and methodological reflection on the relationship between human mobility and energy services that help policy maker to construct new policies and programs to control rural-urban migration in the context of sustainable energy services in Brazil.

Key words: Human Mobility; Energy services; Empowerment

Introduction

According to IEA-2013 [4], Brazil is a leading global energy producer and the largest energy consumer in South America. The large scale green energy production in fast growing, sugarcane and short rotation tree plantations. For example, sugarcane area only in Såo Paulo increased from 2.7 to more than 5 million hectare during the year of 2002-2010 [2], and eucalyptus plantations for pulp is grown in Brazil 5 to 7 years rotation; 40 percent eucalyptus plantations in Brazil. The green energy producers in Brazil, in most cases, do not concentrate land ownership. According to Leen Kuiper (2004), green energy production systems have already created many problems for the local populations in general [10]. Additionally, many studies showed that the production and trade in green energy will not be in line with economic, social and environmental criteria of sustainable human development, which should be worked out through the engagement of local stakeholders [11, 17].

In 2006, Brazil finalized their 'Ten-Years Energy Expansion Plan (PDE 2007/2016)' to address the Millennium Development Goals (MGD). According to UNDP (2010), Brazil's energy issues in relation to MGD address the following specific issues relating to the poor: to promote gender equality and empower women, to ensure environmental sustainability, and to introduce a wide range of interim process of energy reforms (1993) that facilitated the private sector to be involved in a variety of contracts with State-owned companies. According to OECD (2004), these reforms were shaped by changing some of the previous rules of the game that helped them to keep the test of capitalization. That is way thousands of municipalities are still facing problems to enjoy modern energy services. Ironically, these municipalities will remain predominately rural areas [9]. Moreover, Brazil is a country of great inequality, with huge wealth belonging to only 7–10 (approximately) percentages of the total population [15], they are treated the uppermost class, and significant poverty co-existing among approximately 35% of the population. Additionally, Brazilian middle class reached 95 million in 2009 which representing more than half of Brazil's population [9, 18]. This is just because of upheaval social system resulting a large part of the people belongs to poorest of the poor classes. This situation forces many people to migrate their own places. Thus, we would say that human mobility should be an alternative option Brazil's population, not an imposition.[6]

In this paper, authors are also more interested to discuss and to identify how and why or why not human mobility relates with sustainable energy services in Brazil. This discussion will also help us to see 'how worker are deprived from the job position and how they are shifting from one occupation to another'. Many scientists argued that human mobility in relation with energy services in Brazil is specific to the occupation in which an individual works. When an individual switches his/her occupation, they losses the experience accumulated in previous occupation. Besides, many researches and literature reviewed confirmed that energy services already substantial contributions to human development [1, 16].

Aforesaid circumstances highlight (1) social exclusion and the migration of traditional farmers (both small and medium scale) to urban areas to subsist themselves, (2) local people engagement in green energy production because they would contribute to the local economy, and (3) professional capacity – building process for the local workers. This study is intended to enhance understanding the relationship between human mobility and energy services that help policy maker to construct new policies and programs to control rural-urban migration in the context of sustainable energy services in Brazil. Its general purpose is to identify how existing energy systems have been constructed in Brazil. The research questions are as follows:

What about the socio-political situation of sustainable energy services in Brazil? How energy services consider emotional bond between people and valued environment in Brazil? How structural energy services increase the human migration and less mobility in Brazil?

Theoretical Background (The Concept of Human Mobility)

In social sciences, human mobility refers to the movement of a group or an individual member to one place to another [7]. Most human mobility related studies assume a one-dimensional scaling or gradation of in terms of their living status, prestige or status against which movement is then assessed [17, 18]. Thus, downward mobility refers to loss, and upward mobility to increase in social status. Subsequently it is also the degree to which an individual's or group's descendants move up and down the class system. So, it can be said that human mobility is major part of social mobility. In most of the cases are seen that human mobility occur due to societal, economic status or occupational changes. In 2007, for example, Arctic Centre of the University of Lapland conducted a study on rapid environmental and societal changes being faced by people and how these changes influence their institutions and livelihoods. This study found, practical point of view, human mobility mainly occurred when peoples faced grave problem to find their daily subsistence. Additionally, many scholars in the field of both applied sciences and social sciences have classified two types human mobility such as: horizontal

[6] Sources: It is worthwhile to mention as a note of caution that ' Introduction of the study prepared by the authors on the basis of information from the fieldwork , from the CREM Project Reports-Utrecht (2013), Cemig Report (2012), UNDP Report (2010), ECLAC Report (2008), WRM Bulletin 83 (2004), and from literature reviewed. However, 'Results and discussions introduced by authors on the basis of primary sources of information, i.e. fieldwork and somewhat secondary sources of information used as references.

and vertical mobility. If the mobility is a change in position, but not in social class, it is typically called horizontal mobility [13]. But if the move is a change in social class, it is called vertical mobility. Horizontal mobility is very important matter in every society because it is highly related to the job sector of both formal and informal communities. It has an important impact on our social life [6]. When a group or individual change their occupation, there must some important fact like dissatisfaction or better opportunity which change social position. For this reason, horizontal mobility is increasing day by day. For example, in one research on 'United State has shown that, worker are switching their occupation 16% a year in the early 1970s and had increased to 19% by the early 1990s' [11, 19].

Moreover, according to many research scientists like Mike Davis (2006) and Florent Le Nechet (2012), horizontal mobility is very frequently happening, in many developing countries like Brazil, from the bottom level to upper level owing to changes of social status with the bliss of spreading energy and energy related production and service industries in the cities and very few parts of rural areas [4, 15]. Additionally, Kamburove, Gueorgui and Manovskii Iourii (2009) said that in modern world human mobility related with energy services refers that human changed occupations involved with energy services means jobs in energy production lines or energy run production or service industries [6, 7]. In Brazil, for example, human mobility is not only caused by unstable political situation, but also caused by (1) low and inequality of wages, and (2) establishment of energy based industry.

Considering aforesaid discussions, we could say that what author Montanari A. & Staniscia, B. (2012) said, 'Human mobility – an element of synergy and overlap between migration and human centered business- is a key research theme for the practitioners involved in sustainable development research worldwide [13]. In this study, especially, in the results section the term sustainable energy services refer to energy production and utilization in Brazil.

Methodology

In this study, we used two types of data: primary data and secondary data. Considering the nature and types of our study problems, during our research process therefore we engaged in desk reviews of relevant documents pertaining to energy services and human mobility. The documents examined included internal office documents as well as published materials. These documents provided us with a great deal of valuable information about gaps, constraints and successful strategies in relation to human mobility in terms of sustainable energy services in Brazil. In order to collect the primary data we used qualitative research techniques: interviews, observations and focus group discussion. By the use of qualitative approach, we have sought to examine and give voice to those, e.g. ordinary people, who are somehow excluded from modern energy services, in our view, in development decision making and implementation [14]. Study field work was only conducted in state of Såo Paulo. Duration of the fieldwork was only three months (September-November 2013). It is important to mention here that collected information partly used for this paper. A small sample (35) was used to collect the needed information that may not the representative as to other parts of the country, i.e. used information cannot be generalized for the whole picture of the country. We were able to handle this situation by gaining qualitative research methods. It should be noted that to get in-depth and more reliable information small sample is considered to be suitable. Secondly, we conducted our field research only one big state in Brazil that does not reflect the whole energy services picture in Brazil. However, this field research brought a solid information of energy services contains a description of how to address human mobility research, which has both socio-economic and socio-cultural impact of ensuring sustainable energy services in Brazil. This could have been used for further directions on broader empirical research about sustainable green energy production and utilization in Brazil. In this study content analysis was used to determine the presence of certain concepts, topics and, 'identifying unique themes within texts or sets of texts' [3, 12].

Results

Socio-political situation of sustainable energy services in Brazil

According to study people statement both political party and energy commission can partly bring positive changes in green energy services. However, they also said it depends on their good interests that need to be mapped. 32% study people do trust information and energy related issues, while 42% study people do not trust about energy related any information or services, followed by 26% study people provided their mixed opinion. From this micro-level field study it is difficult to say why majority study people are considered human mobility factors to judge their current energy related issues in general. But it could be assumed that they are deprived of standard living in terms of modern energy services. It was observed that ordinary people are happiest on limited amount of information on which to make decision and green energy utilization. Figure 1.1 shows that 12 (34%) of study people mentioned different indicators to measure the level of public knowledge about bioenergy technologies in Brazil. Among them 3 study people strongly recommended that measuring the level of knowledge about bioenergy technologies will require addressing some underlying issues about biomass production in Brazil. In this line of thought, majority study people stressed on further research work in area of social, cultural, economic conditions, and ecological impacts of biomass production in Brazil. It is interesting to note that a very few study people requested us to visit the organizations like, UNICA, AMS, ABRAF, and Sykue to find accurate answers to the questions of interest. Additionally, study people said that by evaluating the accepting of renewable energy and energy efficiency legislation 257589, normative resolution 482/12, and public procurement law 8666/93, we can measure the level of public knowledge about bioenergy technologies. 13 (37%) of study people said they do not have clear information to our research answer , while 29% of study people provided different types of answers to the same research question.

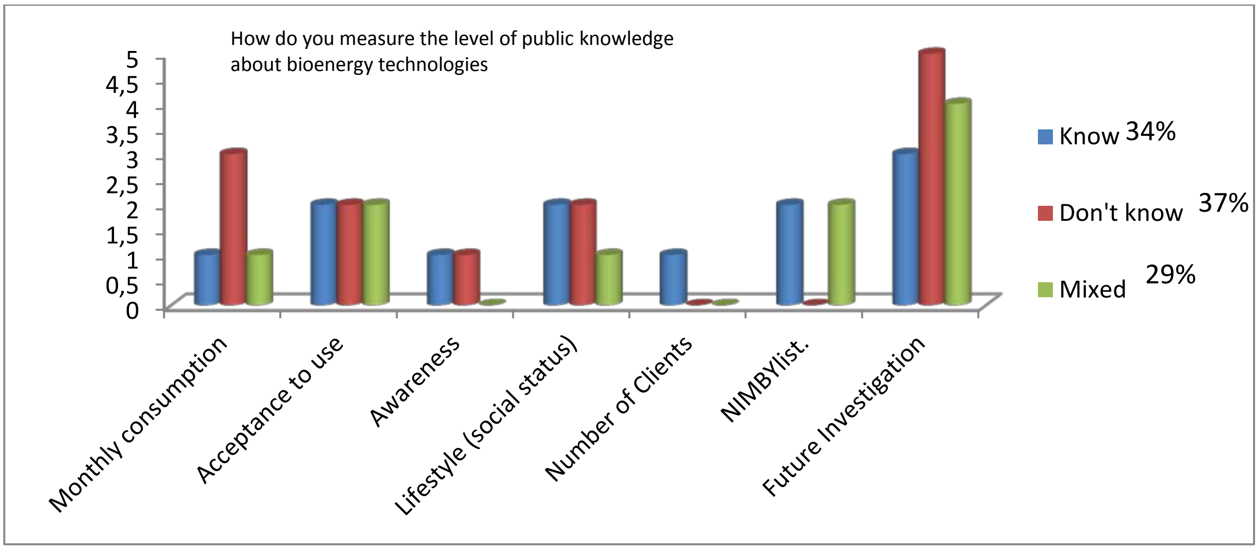

Figure 1.1: The level of study people knowledge about bioenergy technologies.

For example, they have little knowledge, do not really want to share, depends on the uses of bioenergy, it is federal governmental matter and so on. On the other hand table 1.1. shows that political legitimacy in sustainable energy services also caused for increasing human migration and less mobility in Brazil. About 49% study people thought that there are many reasons for considering socio-political legitimacy in green energy in terms of sustainable energy services in Brazil. They said political legitimacy of sustainable energy services is about something political, governmental and civil society organizations. They can prevent human migration from rural to urban areas and increase mobility in energy sectors. Study people more focused on migration in Brazil involved not only in unsustainable exploitation of people and land, but also in structural organizational energy services that primate into the peoples believes and thoughts. At the same time 9% study people said political legitimacy do not necessary encourage people to migrate from rural to urban areas, while 31% of them provided mixed opinion, followed by 11% study said nothing concerning the relationship between political legitimacy and human mobility in energy service sectors.

Table 1.1: The socio-political legitimacy in energy sector

Reasons	Yes (49%)	No (9%)	Mixed (31%)	Don't Know (11%)	Total
Technical issues	2	0	1	1	4
Manage money; Key actors in development sectors	1	0	0	1	2
Commercial issues (new activities, profitable business)	3	0	2	0	5
Play key role in energy	2	0	1	1	4
Organizational issues (new investors, new industry)	1	0	2	0	3
Body constructed by political party, governmental and civil society organizations	3	1	3	1	8
Social issues (situational and behavioral factors)	2	0	0	0	2
Job opportunities	3	2	2	0	7
Total study people	**17**	**3**	**11**	**4**	**35**

In this study we also observed that due to lack of sustainable energy services many local people can not run their small business in need of time. Thus they migrate to urban areas in order to create new business markets, and or to continue their small business, e.g. potters, weavers, and goldsmiths etc.

Communities' perception towards green energy services in Brazil

In this study we observed that most of the study people had mixed and negative conception about green energy production from non-food crops and utilization. That is way study people provided different opinions for answering our field research question. At the same time table 1.2 shows that 14 (40%) of study peoples have different types of beliefs and thoughts about how to consider emotional bond between people and valued environment concerning energy services in general. Their beliefs and thoughts include human ecology of human development factors: (1) institutional factors, (2) external factors, and (3) internal factors. On the other hand, four study people said they have had considered emotional bond between people and valued environment by avoiding competition issues of land with food, sociocultural issues. We observed that all these issues are crucial to be addressed at the both Federal and national policy level. About 13 (37%) of study people provided their different opinions to answer our research question 'how and why do we consider emotional bond between people and valued environment'? For example, study people said: (1) it depends on people's academic background; (2) it depends on how people survive themselves; and (3) it depends on how people accept the new innovations. Additionally, 8 (23%) of study peoples honestly showed their poor knowledge, ideas, trust, perceptions or awareness to answer our research question. Interestingly, during focus group discussion, one participant gave clear answer to our research question. For example, he said that we must have to consider peoples ethical values, social values, socio-cultural values and bonding values in implementing any project and program. These values are embedded in public societal acceptance that requires further study to get accurate and authentic answer from the ordinary people about how we might be able to ensure sustainable energy services in Brazil.

Table 1.2: Considering emotional bond between people and valued environment

Factors	**Yes 40%**	**Mixed 37%**	**Do not know 23%**
Institutional factors	5	2	5
External factors (geographical, social, economic, cultural)	7	7	1
Internal factors (Awareness, values, knowledge, attitude)	2	4	2
Total study people	**14**	**13**	**8**

According to study people statement, sustainable energy services do not address or evaluate what form of energy services is good for the local people in particular. That is why increasing conflicts between energy producers and local people in Brazil. There are many factors that need to be address to gain local people acceptance of sustainable energy service projects in Brazil. For example, table 1.3 shows that 8 (23%) of study peoples showed their strong favour to increase the number of sustainable energy service related projects in Brazil, while 7 (20%) study people said existing sustainable energy service projects do not necessarily consider horizontal factors to ensure well planned program to reduce social and environmental problems. In fact, all study people said that political economy for existing sustainable energy services was devastating small farmers' traditional business sour forever. Thus existing so-called sustainable energy services pushed local farmers to urban job markets in order to find their daily livelihood. Thus they losses the experience accumulated in previous occupation. We observed that there have 'not in my back yard (NIMBY) concerns relating to physical impacts of green energy production both for intra and extra farms. Few study people said that existing green energy services projects have had constructed without considering the combination of some important components: (1) technical capacity development, (2) financial capacity development, and (3) information to increase awareness. As a result, conflicts between energy producers and local community can be seen before, during, and after the implementation of biomass production in Brazil. It is important to note that about 9 study people requested to mitigate all forms of public opposition by gaining their trust and commitment. Thus, to ensure sustainable energy services in Brazil. About 57% of the study people provided their fragile answer to our research question. In fact, there are many lessons for planners and policymakers about how to engage local people in ensuring sustainable energy services in Brazil.

Table 1.3: Factors involve in evaluating green energy services projects in Brazil.

Factors	**Favour 23%**	**Oppose 20%**	**Mixed (favour and oppose) 57%**
Information and social learning	2	1	3
Self-efficacy	1	0	5
Leadership	1	2	3
Knowledge and identity	2	1	2
Culture	1	2	4
Geography	1	1	3
Total study people	**8**	**7**	**20**

Structural relationship between human migration and mobility in energy service sectors in Brazil

Table 1.4: Factors involved in existing institutional framework about green energy services sector in Brazil.

Factors	**Yes (17%)**	**No (20%)**	**Mixed (34%)**	**Do not know (29%)**
Beliefs	2	1	2	2
Leadership	1	1	0	2
Values	0	0	2	0
Attitudes	1	0	1	3
Perceptions	0	1	3	0
Culture	1	0	1	0
Knowledge and identity	0	3	1	3
Experience	1	1	2	0
Total study people	**6**	**7**	**12**	**10**

Table 1.4 shows that about 17% of study people said the existing institutional framework certainly hinders the growth of human mobility in sustainable energy service sector in Brazil. Among them 3 study people said the existing institutional framework does not necessarily consider rational interests that are important, such as good governance and democratic development. About 20% of study people positively expressed their views about improving human mobility in the context of sustainable energy service sectors in Brazil. They mentioned that existing institutional framework has always been considered the dynamics for people engagement in the sustainable energy service sectors in Brazil! Hence, this institutional framework ensures a minimum cost of production and protection of the ecosystem. Thus, it increases income and productivity and encourages people to expand their sustainable energy related business in Brazil. About 34% of study people provided their mixed responses to the research question, while 29% of the study people directly stated that they do not know about the importance of the institutional framework for the sustainable energy service sectors in Brazil. On the other hand, almost all participants of focus group discussions said that the existing institutional framework has constructed through a unique combination of all stakeholder's interests, conditions and their context. However, we observed that the existing sustainable energy service related institutional framework has been constructed, in most cases, without consideration the voices of ordinary people in general. That is why Brazil's government faces challenges to ensure a sustainable energy service market. We also observed that study people provided responses to research question (In your opinion, what is the main factor that hinder sustainable green energy services in Brazil'?) that were shaped by their current psychological status. Thus, the existing sustainable energy service related institutional framework requires addressing relating to what would be the future patterns of public acceptance in terms of a long-term sustainable energy service system in Brazil. According to the participants of focus group discussions, in Brazil,, a large scale energy system (in terms of energy production) is fast growing (e.g, short rotation tree plantations), which accentuates conflicts between the local community versus land use, disrupts the local economy, and changes the delicate power balance. Continuing this line of thought, they do consider that small scale energy system in terms of promoting human mobility in energy services in Brazil. Additionally, study people said that the relationship between investors and intra-farms is fundamental in understanding types of human mobility in the context of sustainable energy services in Brazil. Table 1.5 shows that about 23% of study people said both investors (both inside and outside) and intra-farms have developed a form of mutual trust to keep an independent sustainable energy services, while 40% of study people provided negative answers to research question. Most of the study people said investors want to fully control the intra-small farmers' supply chain. This leads to an unhealthy relationship between investors and intra farms in Brazil. Hence we would say that this relationship do not necessarily encourage intra-small farmers to produce especially more value added energy services in Brazil. Thus, they do not find any alternatives to sustain their existing business. Considering this, intra-small farmers try to reunite to keep their foot in the traditional local market rather than joining the global market. The participants of the focus group discussions also gave almost the same weight in response to our research question. We observed that the relationship between investors and intra-farms has currently been linear, where investors act as the decision makers who order small farmers to take part only in the process of sustainable energy services in particular. This situation also increases migration and decreases mobility in sustainable energy services in Brazil. This particular group of people is involved in many urban factories, e.g. leather, chemical, ceramic, garments, meat etc. Unfortunately, they are employed fewer hours per week than they want. Thus they losses the experience accumulated in previous occupation.

Table 1.5: The relationship between investors and intra-farms

Relationship and energy behavior indicators	Good 23%	Mixed 17%	Do not konw 20%	Not good 40%
Public procurement law implementation	**2**	**2**	**0**	**1**
Institutional structures	**1**	**0**	**0**	**0**
Experience	**1**	**1**	**1**	**4**
Attitude	**0**	**0**	**0**	**0**
Perceptions	**0**	**1**	**0**	**1**
Leadership	**1**	**0**	**0**	**1**
Culture	**0**	**1**	**1**	**0**
Geography	**0**	**0**	**0**	**2**
Awareness	**0**	**0**	**2**	**1**
Beliefs	**2**	**1**	**1**	**1**
Trust	**1**	**0**	**0**	**3**
Knowledge and identity	**0**	**0**	**2**	**0**
Total study people	**8**	**6**	**7**	**14**

Discussion

The study results suggest that weak sustainable energy services in Brazil will lead unemployment and underemployment that highly tends to mobilize in urban areas and out of the countries. More specifically, results suggest that human mobility caused by urban based energy services. In Brazil, there has been substantial migration from rural to urban areas, motivated by the expectation of finding jobs with higher wage rates than are available in agricultural and other rural employments. But people mobilization expectation to have a job at industry in cities; the growth of urban job opportunities exceeds by mobilization resulting in very high urban unemployment rates. Thus the new urban energy structures will undoubtedly led to establish inequality among people and within and between cities of different sizes in Southern American countries like Brazil.

Findings show that most of the people live in rural areas enjoy only 49% electricity. Hence we argue that a more efficient energy supply would boost up the job market in both rural and urban areas in the energy field. Artificial (energy served) lighting would lengthen work days, increase production and create facility of work areas which would make the want of economic emancipation. This study results also show that some causes people have to be departed and consequently become mobilize. Those causes identified as: (a) high growth rate makes landless; (b) unequal income rate changes the traditional professionals; c) modern energy services excluded people; political economy of sustainable energy services; and political legitimacy of energy production and utilization. Large scale plantations in terms of sustainable energy services create an unequal development project imposed on local populations, which also enhance existing conflicts in land use, depriving rural populations of livelihood and traditional sources of income. Thus rural populations migrate from their locals to urban areas in order to find means of daily subsistence. This particular people are landless or homeless of all categories in Brazil mobilize to work in urban areas for better life than in rural areas. They are the most unprecedented social class on earth. Additionally, study results shows that most of the mobilized people get their new jobs in many factories or export processing zone, both are energy service related and a portion of them serves in different plastics, lather, glass, chemical or like these industries as labor or in motor garage which are run by energy.

The study results also show that potters, weavers, goldsmiths, or blacksmiths are mobilizing to the areas of available electricity to be easier to jobs and more production or to change the profession. However, this jobs situation, in most cases, help to loss their experience accumulated in previous occupation. Besides, the rural dwellers are mobilizing to the urban areas and creating the same job markets there having the energy facility and they are well to do with the bless of energy services. The findings of this paper show that local people who works at rural and urban areas now works their and it is only the energy helps to establish a factory like this. Thus people mobilize there and its cause is to energy.

Conclusions

In this paper, discussion and observation on human mobility in the context of sustainable energy services in Brazil clearly reflects that energy can create multidimensional new fields of jobs and making job markets which can keep free from the curse of unemployment. Additionally, in this paper we have also seen that non-ethics and politically exploitative energy services cause uncontrolled human mobilization resulting in very high urban unemployment. More specifically, in Brazil, rural people migration and unemployment in urban areas caused by unsustainable energy services, which means that a large number of people are employed fewer hours per week than they want. Sustainable energy services at local level require geographically located information, current land uses, local political jurisdictions, land ownership, location of cultural and historical resources, and of preserves habitats and species. In addition to this, in this paper we have further seen that the high rate of horizontal human mobility in Brazil that simply also caused by unsustainable pattern of energy services. It may be argued here that energy services act like the magnet to attract the happiness of human in general. Hence, the humankind needs energy services can help us to construct context based energy related new policies and programs to ensure less migration and more mobility in energy services in Brazil. More specifically, if energy distribution would be made according to the inhabitant ration in both rural and urban areas then, the economic growth as well as the social development would be elevated and human mobility in terms of rural-urban migration in the context of sustainable energy services in Brazil could be apparently controlled.

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Global Transport Biofuel Futures in Energy-Economy Modeling – a Review

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The high oil dependence and the growth of energy use in the transport sector have increased interest in alternative fuels as a measure to mitigate climate change and improve energy security. More ambitious energy and environmental targets and larger use of alternative energy in the transport sector increase system effects over sector boundaries, and while the stationary energy sector (e.g., electricity and heat generation) and the transport sector earlier to large degree could be considered as separate systems with limited interaction, integrated analysis approaches now grow in importance. In recent years, the scientific literature has presented an increasing number of energy-economic future studies based on systems modeling treating the transport sector as an integrated part of the energy system and/or economy. Many of these studies provide important insights regarding transport biofuels. To clarify similarities and differences in approaches and results, the present work reviews studies within this field and investigates what future role comprehensive energy-economy modeling studies portray for transport biofuels in terms of their potential and competitiveness.

Introduction

The high oil dependence and the growth of energy use in the transport sector have increased interest in alternative fuels as a measure to mitigate climate change and improve energy security. Local air pollution is also a driver for finding alternatives to conventional petrol and diesel based on crude oil. Alternatives to conventional diesel and petrol include biofuels, hydrogen, electricity or synthetic fuels from, e.g., coal or natural gas.

Biofuels currently only contributes to a small share of the energy supply to the transport sector; while the global use of transport biofuels is about 2.5 EJ, the total final fuel use in the sector is about 100 EJ (OECD/IEA, 2012). However, several governments and intergovernmental organizations have policy targets aiming at a future increase in transport biofuel use, e.g. in the EU, the share of fuels from renewable sources in the transport sector should amount to at least 10% of the total transport fuel use by 2020 (EC, 2009).

While the stationary energy sector (e.g., electricity and heat generation) and the transport sector earlier to large degree could be considered as separate systems with limited interaction, more ambitious energy and environmental targets and an increased utilization of alternative energy carriers in the transport sector can be expected to have system effects over sector boundaries. This is due to several reasons, e.g. competition for biomass resources, which can be used both for biofuel production and/or heat/power production. All different types of biomass use compete at some level, ultimately due to land scarcity. Further, plants co-producing several outputs, such as biofuels, heat and electricity stress the role of system interactions. Electric cars, as well as hydrogen production based on electrolysis, also affect the electricity generation system by increasing demand and, possibly, by evening out the load curve and allowing more intermittent generation in the system. Interaction over sector boundaries is also a factor from an environmental and climate economic perspective; both the stationary energy sector and the transport sector give rise to greenhouse gas (GHG) emissions and fill up a common (politically and/or environmentally set) emission quota. Since economical resources are limited, a system-wide allocation strategy is imperative.

Methodological approaches in which individual parts of the energy- and transport system are investigated separately have been, and still are, common in environmental and energy systems planning and future studies.

However, as the importance of dynamic interactions over sector boundaries increase, an expanded systems view in which the co-evolution of an integrated energy and transport system is analyzed increase in relevance. In recent years, a growing number of energy-economic future studies based on systems modeling treating the transport sector as an integrated part of the energy system and/or economy have emerged in the scientific literature. Thus, important insights regarding the potential future role of transport biofuels, with potential system wide effects taken into account, can be provided. The interpretation and implications of the model results presented in the literature can, however, be complex.

There are several modeling studies applying a system-wide perspective on the future role of transport biofuels, but synthesis studies of this field are rare. To clarify similarities and differences in approaches and results of modeling studies providing insights on transport biofuel futures, the present work seeks to review and synthesize studies carried out within this field. Questions of investigation are:

- What future role do comprehensive global energy-economy modeling studies portray for transport biofuels in terms of their future potential and competitiveness?
    - What future utilization levels for transport biofuels do the studies depict as likely/cost-effective?
    - What factors influence differences in results?
    - What overall insights can be made based on the aggregate results of the studies?

This review is not intending to cover every study that has some relevance to the area but rather a selection is done limiting included studies to more recent scientifically reported modeling studies with global energy system coverage. Further, included studies should have a comprehensive systems approach treating the transport sector as an integrated part of the energy system and/or economy. In addition, included studies should be applying a medium-term to long-term time horizon, tbe of relevance from a transport biofuel perspective and, preferably, focus on the transport sector. These selection criteria have resulted in seventeen studies to be covered by this review; a sufficiently large number of studies to enable the formation of justifiable general insights.

The studies

Global energy-economic systems modeling can be an important tool in future studies on how to achieve a more environmentally friendly future transport and energy system. Regarding transport biofuels, it can give significant insights to what future market penetration level that is feasible, cost-effective and/or likely on a global level. In this section, the approach of a number of recent global systems modeling studies are looked into.

The bulk of recently published modeling studies utilizing a global approach and analyzing questions related to future use of transport biofuels are based on bottom-up, optimization energy system modeling. In the models used in these studies, fossil energy resources are generally described by an, over the studied time period, accumulated available resource base and related extraction costs. Renewable options such as biomass are also limited but their availabilities are generally linked to a model year, i.e. a maximum potential use of biomass per year is assumed. The models are to different degree regionalized; while some models see the world as one global region with, e.g., unlimited possibilities of trade and allocation of emission reductions between countries and continents, others are disaggregated into different geographical world regions. In the latter case, this allows for the inclusion of model features such as restrictions in trade between regions, regional caps for CO_2 emissions and regional targets for transport biofuel use. In global models, energy prices are to large degree decided endogenously as a function of the final demand for a certain resource, although the studies also at times include sensitivity analyses of different energy price developments. *Table 1* summarizes selected global modeling studies that will be closer looked into as well as some of their respective model features.

Table 5. Selected global modeling studies and their related model features.

Reference	Model – Regionalization	Model characteristics	End-year
Takeshita & Yamaji (2008); Takeshita (2012)	REDGEM70 – 70 regions	Optimization, Partial Equilibrium, Perfect Foresight, Bottom-Up	2100
Turton (2006)	ECLIPSE – 11 regions	Optimization, General Equilibrium, Perfect Foresight, Hybrid, Endogenous Technology Learning, Elastic Demand	2100
Azar et al. (2003); Grahn et al. (2009a, 2009b); Hedenus et al. (2010)	GET – 1; 6/10; 1 region(s)	Optimization, Partial Equilibrium, Perfect Foresight, Bottom-Up	2100
Gielen et al. (2002, 2003)	BEAP – 12 regions	Optimization, Partial Equilibrium, Perfect Foresight, Bottom-Up, Elastic demand	2040
Gül et al. (2009)	GMM (MARKAL) – 6 regions	Optimization, Partial Equilibrium, Perfect Foresight, Bottom-Up, Endogenous Technology Learning	2100
Fulton et al. (2009), IEA (2008)	ETP (MARKAL) + MoMo (model-linking) – 22 regions (MoMo)	Optimization (ETP)/Simulation (MoMo), Partial Equilibrium, Perfect Foresight, Bottom-Up, Endogenous Technology Learning, Elastic Demand	2050
Anandarajah et al. (2013)	TIAM-UCL (TIMES) – 16 regions	Optimization, Partial Equilibrium, Perfect Foresight, Bottom-Up, Endogenous Technology Learning, Elastic demand	2100
Akashi & Hanaoka (2012)	AIM/Enduse[Global] – 32 regions	Optimization, Partial Equilibrium, Dynamic recursive, Bottom-Up	2050
van Ruijven & van Vuuren (2009)	TIMER – 26 regions	Simulation, System Dynamics, Bottom-Up, Endogenous Technology Learning	2050
Kitoues et al (2010)	POLES – 12 regions	Simulation, Partial Equilibrium, Recursive, Bottom-up, Endogenous Technology Learning , Elastic Demand	2100
Kyle & Kim (2011)	GCAM– 14 regions	Simulation, Partial equilibrium, Dynamic-recursive (myopic), Elastic Demand	2095

Takeshita and Yamaji (2008) and Takeshita (2012) develop and utilize the REDGEM70 model. REDGEM70 is a bottom-up type, global energy systems linear optimization model which is regionally disaggregated into 70 regions. The model has a long-term time horizon reaching from 2000 to 2100. REDGEM70 considers a number of energy conversion technologies as well as carbon capture and storage (CCS) in power generation, oil refinery and in production of synthetic fuels. The model includes several technologies for production of alternative transport fuels, e.g., hydrogen, methanol, dimethyl ether (DME), Fischer-Tropsch (FT), bioethanol and biodiesel.

Turton (2006) describe a sustainable automobile transport scenario by analysis with the integrated assessment model ECLIPSE. ECLIPSE incorporates the energy systems model ERIS with macroeconomic and passenger transport demand models and further linked to the climate model MAGICC. The ERIS model is a bottom-up optimization model for study of the global energy system.

GET is an energy system model for the study of long-term development of the global energy system under carbon constraints. GET is a bottom-up model based on linear optimization driven by exogenously given energy demands in four different stationary end-use sectors as well as transportation demands divided into different transport modes. Published studies to a high degree focus on the cost-effective fuel choices in the transport sector and system-wide effects associated with this. The model was originally developed by Azar et al. (2003) and has subsequently been further developed and used by Grahn et al. (2009a, 2009b) and Hedenus et al. (2010). Grahn et al. (2009a, 2009b) regionalized the model, and Hedenus et al. (2010) added detail to the representation of the heat sector in the model.

A further example of a bottom-up optimization global energy system model is the BEAP model, developed by Gielen et al. (2002, 2003). The model is utilized to study the optimal use of biomass for GHG emissions reductions. The BEAP model is based on mixed integer programming, in which the development of the system is decided through maximization of the sum of the consumers' and producers' surplus. Focusing on biomass systems, the BEAP model covers the global energy, food and materials system and divides the world in 12 regions.

MARKAL is a well-established energy system model framework, which can be combined with different databases and, in such way, form different model applications. MARKAL models are of bottom-up, optimization type and generally based on linear programming. Gül et al. (2009) utilize a global 6-world region MARKAL model, denoted the Global Multi-regional MARKAL model (GMM). In this case, the bottom-up energy system model is linked to the climate change model MAGICC (in a similar manner as Turton, 2006). GMM has a detailed representation of alternative fuel chains.

Fulton et al. (2009) present transport-related results and modeling from the IEA study "Energy Technology Perspectives" (IEA, 2008) in which a combination of the MARKAL based IEA-ETP model and the IEA Mobility Model (MoMo) is utilized. MoMo is a spreadsheet model aimed at estimating and projecting travel indicators, energy consumption, pollutant emissions and GHGs generated for worldwide mobility.

The ETSAP-TIAM model is a TIMES based model describing the global energy system. TIMES (an acronym for The Integrated MARKAL-EFOM System) is an update of the MARKAL modeling framework. Anandarajah et al. (2013) give special focus to the road transport sector (using a version of the model referred to as TIAM-UCL) and investigate the role of hydrogen and electricity to decarbonize the transport sector.

In a similar manner as MARKAL and TIMES, the AIM/Enduse model framework has been utilized combined with different databases and in different studies to analyze national energy systems as well as the global energy system. Akashi and Hanaoka (2012) examine the technological feasibility of large cuts in GHG emissions. The global version of AIM/Enduse model, AIM/Enduse[Global], which is used in this study, splits the world into 32 regions over a time horizon from 2005 to 2050.

The above described models rely largely on optimization in the choice of future fuel and technologies. Other models apply more of a simulatory approach and also seek to incorporate other aspects in technology choices made. Van Ruijven and van Vuuren (2009) explore the energy system impacts of different future hydrocarbon prices, using the global energy model TIMER. The TIMER model, which is part of the integrated assessment model IMAGE, describes the long-term dynamics of the production and consumption of energy carriers in 26 global regions. Here, costs combined with preferences are used in sectoral multinomial logit models in the selection of technologies.

Also the POLES model can be described as utilizing a simulating approach. POLES have been used in various studies at both national and international level. Kitoues et al. (2010) present a long-term assessment of the worldwide energy system in scenarios ranging from a baseline to a very low GHG stabilization using the POLES model.

The GCAM model (previously known as MiniCAM) is a long-term, global, technologically detailed, partial-equilibrium integrated assessment model that includes representations of energy, agriculture, land-use and climate systems. The model calculates equilibrium for energy goods and services, agricultural goods, land and GHG emissions. Using the GCAM model, Kyle and Kim (2011) assess global light-duty vehicle (LDV) transport and the implications of vehicle technology advancement and fuel-switching on GHG emissions and primary energy demands by simulating five different technology scenarios.

Scenarios applied

Global modeling studies often apply climate policies with exogenously determined targets for future atmospheric concentration CO_2 levels. The use of biofuels in the transport sector is contrasted to fossil transport fuels and often also other potential low-carbon transport options, which generally are based on either hydrogen or electricity. Table 2 summarizes model input data related to transport sector technology representation and scenario assumptions.

While many studies present a number of different model scenarios with different input data and assumptions, here we focus mainly on the scenarios with stringent climate polices. Most of the studies apply a stabilization target for atmospheric CO_2 concentration, but some studies instead apply an exogenous CO_2 penalty cost.

The representation of fuels and technologies in the transport sector is of importance for the outcome of the models and also how the outcome should be interpreted. Many of the studies treat biofuels in aggregate and thus only include a single generic biofuel fuel option, even though this “biofuel” might be denoted biomass-to-liquid (BtL), synthetic fuel, methanol, or simply “biofuel”. Other studies include a range of biofuel options.

Table 2. Climate ambition, biomass potential and fuel and technology representation in road transport for selected studies. Blanks indicate that info were unclear or could not be obtained.

Reference	Climate policy or target	Max biomass per yr	Technology representation road transport		
			Biofuels	Other low carbon options	Vehicle technologies
Takeshita and Yamaji (2008)	550 ppm	300 EJ (2050); 250 EJ (2100)	Biodiesel, EtOH, biogas, FT- liq., DME, MeOH, H2	H2	ICEV, HEV, FCV
Takeshita (2012)	400 ppm	300 EJ (2050); 250 EJ (2100)	Biodiesel, EtOH, biogas, FT- liq., DME, MeOH, H2	H2, Electricity	ICEV, HEV, EV, PHEV, FCV
Turton (2006)	550 ppm	235 EJ (2050); 320 EJ (2100)	H2, alcohol, FT- liq.	H2	ICEV, HEV, FCV
Gül et al.(2009)	450 ppm	195 EJ	Biodiesel, FT-diesel, EtOH, MeOH, DME, bio-SNG, H2	H2, Electricity	ICEV, HEV, EV, PHEV, FCV
Azar et al. (2003)	400 ppm	200 EJ	MeOH, H2	H2	ICEV, FCV
Grahn et al. (2009b)	450 ppm	205 EJ	BtL , H2	H2	ICEV, FCV
Hedenus et al. (2010)	400 ppm	200 EJ	Synthetic fuel , H2	H2, Electricity	ICEV, HEV, EV, PHEV, FCV
Gielen et al. (2003)	80 $/tCO_2$ cost (75% CO_2 red.)	Depends on land prices calculated by the model.	MeOH, FT-gasoline, EtOH	No	ICEV
Akashi and Hanaoka (2012)	Cost incr. from 0 to 600 $/tCO_2$ in 2000-2050 (50% CO_2 red.)	364 EJ	"Biofuel"	H2, Electricity	ICEV, HEV, EV, PHEV, FCV
Van Ruijven and van Vuuren (2009)	100 $/tCO_2$ cost (10-45% CO_2 red.)		"Biofuel"	H2	ICEV
Kitoues et al (2010)	400 ppm	200 EJ	"Biofuel", H2	H2 Electricity	ICEV, HEV, EV, PHEV, FCV
Anandarajah et al. (2013)	Global mean temp. not rise more than 2°C	Probably about 100-150 EJ [b)]	Biodiesel, EtOH, H2	H2 Electricity	ICEV, HEV, EV, PHEV, FCV
Fulton et al. (2009) *IEA (2008)*	450 ppm	Not clear (results = 150 EJ)	Biodiesel, EtOH, BtL (BtL biodiesel, LC ethanol)	H2 Electricity	ICEV, HEV, EV, PHEV, FCV
Kyle and Kim (2011)	Cost incr. from 10 to 400 $/tCO_2$ in 2020-2095 (450 ppm)		BtL, biomass-based gas	H2, Electricity	ICEV, HEV, EV, PHEV, FCV

Biofuel utilisation

The reviewed global model studies provide different insights about the future potential and competitiveness of biofuels in the transport sector. The resulting transport biofuel market shares are visualized in Figure 1. The resulting transport biofuel utilization and market shares range from small to large. For most scenarios, the transport biofuel share stays below 40% and several scenarios show very low levels (0–10%). Studies showing biofuel market shares above 40% not only rely on "regular" biofuels but also on hydrogen based on bio-energy with carbon capture and storage (BECCS). Even though market shares for transport biofuels in most of the scenarios stay at low-medium levels, many of the scenarios show a significant increase in biofuel use in absolute terms compared to today's level of 2.5 EJ (out of the total final transport sector fuel use of about 100 EJ; OECD/IEA, 2012). Thus, the results suggest an increase in transport biofuel use compared to today's level but, at the same time that transport biofuels do not tend to dominate the future transport sector.

Many of the studies only include a single aggregate biofuel option and, thus, provide no insights in regard to which biofuel type is preferable. Among the studies that do point out specific biofuel options, Takeshita and Yamaji (2008) and Takeshita (2012) highlight FT liquids (synthetic diesel, gasoline and kerosene) as one advantageous alternative, partly due to its potential to fuel the aviation sector. Akashi and Hanaoka (2012) and Turton (2006) point out bio-hydrogen combined with BECCS and Turton (2006) also favor bio-alcohol over FT liquids. Fulton et al. (2009) mention ethanol as well as FT liquids.

By comparisons of the scenario results, from different studies as well as sensitivity analyses within studies, a number of factors that often are of importance for the biofuel utilization in the global model results can be identified. Important factors for global model studies include biomass potential, climate ambition and technology model representation for the transport sector as well as for the stationary energy system.

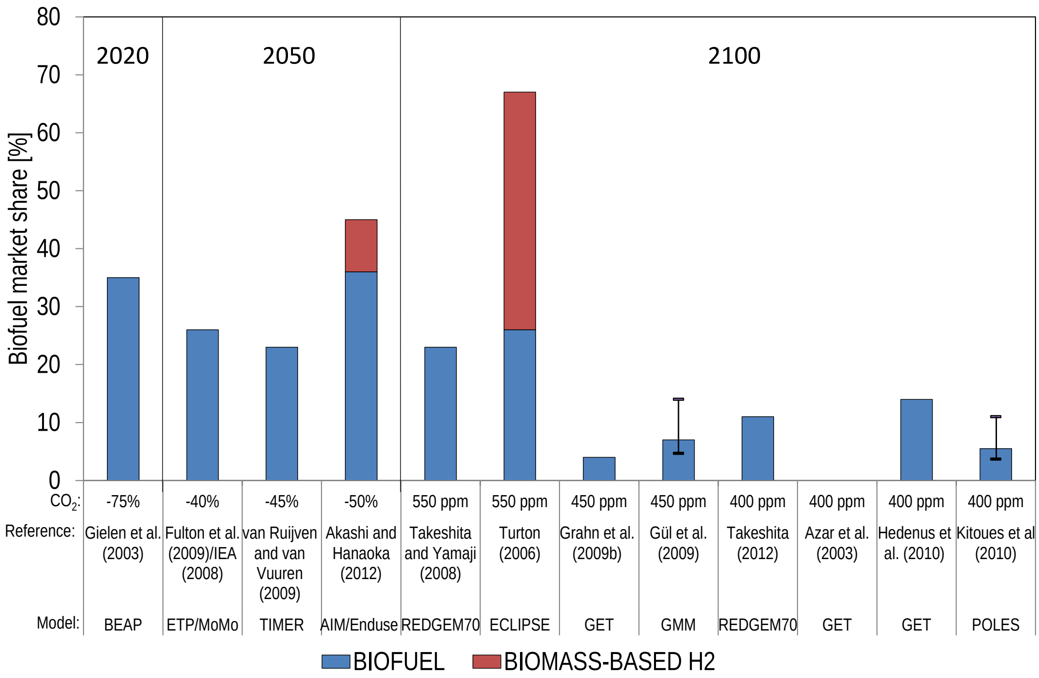

Figure 1. Biofuel market shares at model end-year for some of the reviewed global studies. For Gül et al. (2009) and Kitoues et al. (2010), shares have here been calculated assuming a total final transport energy use of 200 EJ and ranges indicating shares for 100-300 EJ total final energy (due to lack of data).

The future potential availability for biomass for energy purposes is subject to various conditions such as land use, food demand and agricultural productivity, and estimations of future potentials are linked to uncertainty. The reviewed global modeling studies show significant differences in regard to biomass potentials. For example, Akashi and Hanaoka (2012) and Turton (2006), at the end of their modeled time horizons, assume biomass potentials of 364 EJ and 320 EJ, respectively, while, for instance, Grahn et al. (2009) and Kitoues et al. (2010) assume levels around 200 EJ. While the former mentioned studies present a widespread use of transport biofuels in their results, the latter mentioned studies show significantly smaller shares of transport biofuels. Several of the studies also highlight biomass availability as a central constraint for transport the utilization of transport biofuels. Gül et al. (2009) conclude that the key limiting factor for a further deployment of biofuels is the availability of biomass and that biomass is more cost-effectively utilized in electricity and heat production in a carbon constrained world. Sensitivity analyses of different studies in which the biomass potential is increased generally also increase the deployment of transport biofuels in stringent climate scenarios (e.g., Azar et al., 2003; Grahn et al., 2009b) although there are exceptions (Anandarajah et al., 2013).

In regard to technology representation in the transport sector, the availability of low carbon options in addition to biofuels is of significance for the competitiveness of transport biofuels. In particular, an assumed high potential for low cost hydrogen FCVs or electric vehicles would reduce the competitiveness of biofuels, and vice versa. Since the models generally apply a long time horizon and often assume decreasing costs for new technologies over time, there is also a time aspect to this.

In many of the reviewed studies, electricity and non-biomass-based hydrogen obtain dominating positions in the transport sector at the end of the studied time horizons, see e.g. Gül et al. (2009), Van Ruijven and van Vuuren (2009), Anandarajah et al. (2013), and Grahn et al. (2009b). However, Gielen et al. (2003) obtain a significant contribution of transport biofuels in the results and no hydrogen or electricity. As previously highlighted by Grahn et al. (2007), the BEAP model lacks representation of low-carbon alternatives in the transport sector other than biofuels, while several low-carbon options were represented in the stationary energy system. Thus, as carbon targets become strict, the transport sector of the BEAP model has no other option than turning to biofuels.

Turton (2006) and Akashi and Hanaoka (2012) are among the studies that obtain the highest biofuel utilization. As showed in Figure 1, this is a result of utilization of both "conventional" biofuels and a considerable share of biomass-based hydrogen production in combination with BECCS. Several studies exclude the latter alternative (hydrogen production with BECCS) in their models. Whether this option is included or not is of relevance for the competitiveness of biomass-based hydrogen production compared to non-biomass based options.

Not only is the nature of the representation of technology options in the transport sector of significance for the resulting transport biofuel utilization, but so are choices made in regard to technology representation of the stationary energy system. The availability of future low-cost, non-biomass based low carbon electricity generation can be a significant contributing factor to a high transport biofuel use, since this lowers the demand for biomass in the stationary energy system. In the reviewed studies, this can be noted in scenarios allowing a high use of nuclear power generation and/or electricity generation based on CCS. These are two low-carbon options for electricity generation, with technically high potential, which for future conditions often are assumed to have relatively low costs compared to other options, such as solar power. However, their deployment is to large degree dependent on political and public acceptance issues. Partly due to this, assumptions regarding these technologies differ widely.

Another aspect of technology representation in the stationary energy system of importance for the resulting transport biofuel utilization is to what degree biomass can supply industrial process heat demands. Hedenus et al. (2010) increase the level of detail in regard to process heat demand and introduce limitations for the amount of biomass allowed in the GET model, resulting in higher transport biofuel utilization than in other GET modeling studies. Similar limitations may be of significance also in other models.

The impact of the assumed climate ambitions, i.e. the level of GHG reductions that should be met, on the level of transport biofuel utilization is not entirely straightforward. Generally, no-policy scenarios end up with a low use of bioenergy in general and transport biofuels in particular. The reason for this is simply that there are cheaper energy sources available, such as coal. Exceptions to this are given by Van Ruijven and van Vuuren (2009) who present significant transport biofuel usage also in such scenarios. This is most likely explained by high oil price assumptions combined with the model's lack of representation of low-cost coal-based liquid synfuels.

With increasing climate ambitions and thus higher CO_2 emission penalties, bio-energy increase in competitiveness compared to fossil fuel options. For "medium" climate ambitions (e.g., 550 ppm), a certain amount of transport biofuels is also cost-effective in many of the reviewed studies. However, for very stringent climate targets, results are more diverse. Grahn et al. (2009b) and Gül et al. (2009) suggest that the cost-effective transport biofuel usage tends to peak at medium CO_2 reduction targets. While fossil-based transport fuels are likely to dominate at less ambitious reduction targets, more stringent targets increases the cost-effective transport biofuel usage, but as reduction targets increase even more, the models tend to choose other low-carbon options for the transport sector (hydrogen and/or electricity) while allocating biomass resources to heat and power production in the stationary energy system.

Discussion

In the present work, a number of model-based studies, in which the transport sector is represented as an integrated part of the global energy system and transport biofuels constitute an important part of the analysis, have been reviewed. The review provides insights into the level and characteristics of the transport biofuel utilization in these studies and to factors influencing their model results.

In terms of results and insights, the review demonstrates that energy-economic modeling studies portray a diverse picture in regard to the future transport biofuel utilization. However, most studies shows biofuel share below 40% at the end of the modeled time-horizon, with several studies showing results well below this level.

Not all studies are concerned or explicit about which type of biofuel is the most advantageous choice. However, among studies including a number of different specified biofuel options in the modeling, some trends emerge. Generally, liquid wood-based second-generation biofuels and, more specifically, FT liquids are an option that is highlighted in several of the studies. The possibility of using existing infrastructure and vehicles is, in these cases, probably of high significance, but also the combined production of jet-fuels (for the aviation sector) and synthetic diesel/gasoline (for the road transport sector) of the FT process is pointed out as valuable. Also other biofuel types, such as biomass-to-alcohol, are mentioned as advantageous options in different studies but less frequently than FT liquids.

A number of factors influencing the resulting transport biofuel utilization in the modeling results have been identified. These are mainly biomass potential, climate ambition/policies, and technology representation in the transport sector as well as in the stationary energy sector. Since the models cover long time horizons and the conditions often change over time there is also a time aspect to many of the mentioned factors (e.g., technology costs, CO_2 reduction requirements and energy prices).

The *climate ambition* (the level of GHG reduction constraints or emission cost penalties) is relevant for how much of the available biomass is used. With higher climate ambition, the proportion of the total biomass potential that is used increases.

The *technology representation*, i.e. what technologies that are available in the model, to what relative costs and to what potential, determine the allocation of biomass. The relative cost of alternative technologies is complex and varies with scarcity rents and CO_2 penalties, which, in turn, are functions of the climate ambition. This relates to transport biofuels in relation to other technologies in the transport sector as well as in the stationary energy system, but also between different transport biofuel options. For example, favorable assumptions regarding non-biomass based low-carbon electricity generation, such as CCS or nuclear power, imply a low demand for biomass in the stationary system and, in many cases, this means more available biomass for transport biofuel production. On the contrary, a high (allowed) potential and low costs for hydrogen or electricity-based transportation will decrease the competitiveness of transport biofuels. A high total *biomass potential* can imply that the potential of the most cost-effective biomass usage can be filled and still leave biomass resources to other, less cost-effective, alternatives.

The transport biofuel utilization in the model results depends on several factors and many studies show large differences. Differences depend in many cases on quantitative assumptions regarding more or less uncertain input data. While this highlights difficulties with quantitative long-term future modeling of energy-economic systems, it also demonstrates a strong relevance of the same: without making quantitative statements regarding numerous parameters (such as biomass potentials, cost of alternative technologies, system-wide CO_2 reduction aimed for), not much can be said about the future effective contribution of transport biofuels from an overall system perspective.

Conclusions

In this review of future studies based on global energy systems modeling, we find that the future market penetration of transport biofuels range from low to high levels in the reviewed model results. Most of the studies show low to intermediate biofuels market shares (below 40%) at the end of the studied time horizons for climate policy scenarios not including sector specific polices. Factors influencing biofuel utilization in the model results include: biomass potential, climate ambition/policies, technology representation in the transport sector and in the stationary energy sector, oil price, and energy policies in addition to GHG related constraints or penalties.

Although transport biofuels do not tend to dominate the transport sector at the end of the modeled time horizons, compared to today's level many model studies show a significant increase in transport biofuel use. Besides transport biofuels, the development and deployment of energy efficient vehicle technologies, such as plug-in hybrids and FCVs (in the longer term), is an essential part in many of the future transport scenarios.

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NORTH-SOUTH RESEARCH COLLABORATIONS – FOR WHOM AND FOR WHAT?

Climate Change Immigrants or Refugees – Adapting to or Denying Climate Change?

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Climate change immigration and refuge (asylum) seeking have taken place all through the ages, but now their scales are predicted to become global, involving billions of displaced people. This paper builds a model that aims to turn chaotic climate refuge seeking into planned climate migration by learning from history. It uses qualitative case studies derived from literature and compiled into a framework as a research method.

Introduction and Background

People have migrated and taken refuge all through the ages for a great variety of reasons. These include political, economic, social, cultural and environmental motives, often an entanglement of many. Early humans migrated from Africa to Europe and throughout the Eastern Hemisphere as far as Australia where the Aboriginals settled (Manning 2013). Later, the Huns from Asia and other tribes invading the declining Roman Empire pushed Europeans into the great migration period 400–800 BC (Heather 1995). The "discovery" of America by Christopher Columbus in 1492 started mass migration of Europeans to Western Hemisphere, although people from Asia had migrated there already 16,000–40,000 years ago forming tribes of Native Americans. Religious persecution initiated another mass migration from Eastern Hemisphere to America in the 17th century (Kuparinen 2013). Yet another, more economic mass migration wave from Europe to North and South America took place 1820–1930 (Daniels 2002, Kuparinen 2013, UN 2004). World War II created 60 million refugees (Bade 2003).

Subsequent wars, political and ethnic conflicts, disasters, and erosions of ecological and socio-cultural environments have continued to produce masses of refugees globally. Voluntary migration, on the other hand, has been largely individually motivated permanent resettlement or temporary movement. Nowadays most voluntary immigrants are well-to-do executives, experts and skilled workers employed by multinational corporations or free academic and artistic souls. At the other extreme are the refugees fleeing persecution. Their numbers amount to 45 million of which international refugees account for 15 million (UNHCR 2013). Many of them have been somewhat cynically labelled economic refugees as their motives are intertwined: they come from war zones or otherwise chaotic societies where their life or freedom is threatened and wish to build a normal life with a good livelihood in a peaceful, orderly society. The rich–poor polarization may increase or decrease in the future, depending on how countries and the global community respond to new challenges.

Immigration is a part of globalization, just like climate change. The unpleasant future prospect of immigration is climate change immigration, which has taken place all through the ages, but not on such a scale as predicted now. The even more unpleasant future prospect of refuge (or asylum) seeking, already present in many areas, is climate change refuge seeking, which may explode into uncontrollable floods, if not organized into controllable flows.

People who seek refuge are called asylum seekers until their claim has been definitely evaluated to warrant a refugee status (UNHCR 2014). The United Nations Refugee Convention from 1951 says that a refugee is any person who, "owing to a well founded fear of being persecuted for reasons of race, religion, nationality, membership of a particular social group or political opinion" (UNHCR 1951, 14). Climate change is not yet included in the reasons for gaining a refugee status (Morinière 2009, 22); hence climate refugee and climate refuge seeking are still theoretical concepts.

This paper aims to build a model that turns chaotic climate refuge seeking into planned climate migration by learning from history. It uses qualitative case studies derived from literature and compiled into a framework as a research method. The cases used are summarized in the following sections and figure 1.

Climigrants and Clirefugees

Climigration is the concept Bronen (2009) uses for forced permanent migration of communities due to climate change. I suggest that climigrants may belong to three groups of environmental migrants defined by Renaud *et al.* (2008): (1) environmental emergency migrants who must flee because of rapid onset events and take refuge to save their lives; (2) environmentally forced migrants who are compelled to leave to avoid gradual environmental deterioration and may not have a choice to return; and (3) environmentally motivated migrants who choose to leave a deteriorating environment in order to avoid further weakening of their livelihoods (see also Morinière 2009).

El-Hinnawi (1985, 4, cited in Lübken 2012, 6) called environmental refugees "people who have been forced to leave their traditional habitat, temporarily or permanently, because of a marked environmental disruption […] that jeopardized their existence and/or seriously affected the quality of their life". I suggest that in synchrony with climigration, the concept of clirefuge could be used of seeking climate change refuge. Whether people having to move because of climate change should be called climigrants or clirefugees is a topical issue.

A family from the sinking South Pacific nation of Kiribati tried to challenge in New Zealand in 2013 the International Refugee Convention's (UNHCR 1951) position that climate change is not a reason to give a refugee status, but the fact that the Kiribatians are facing risk to their health and lives as rising ocean levels are contaminating drinking water, killing crops and flooding homes did not convince the High Court (Schwartz 2013). Kiribati has now bought land in Fiji to grow food and build a resettlement site for its displaced people. Moreover, Kiribati has adopted a "migration with dignity" approach by teaching its people skills to become more attractive as immigrants (Reklev 2014). Kiribatians wish to stay as independent and self-sufficient as possible, maintain their cultural identity and live sustainably (Randall 2013). Other famous low-lying Pacific islands like this are the Maldives, Tuvalu and Vanuatu (Lazrus 2009, Marino 2009, Farbotko and Lazrus 2012, Nanda in the Foreword of Westra 2009). Contrary to the Kiribatian family's fate, New Zealand's Immigration and Protection Tribunal granted a

Tuvalu family residency in 2014, because the family had children who were considered to be more vulnerable to climate change – but emphasized that climate change was only one of the factors leading to granting residency on "exceptional humanitarian grounds" (ABC News 2014).

The UNHCR's reluctance to extend its concept of refugee to incorporate clirefugees is due to the special status of refugees, which gives them access to services and resources in their resettlement country unavailable to other migrants (Bronen *et al* 2009). The socio-economic burden of countries accepting clirefugees might become unbearable with prospective mass exoduses. Yet in some countries, such as Sweden and Finland, laws allow people fleeing their country because of environmental disaster to be qualified for refuge (Sgro 2009).

Sources and Directions of Climigrants and Clirefugees

Bronen (2009, 68) segregates the drivers of climigration into three categories: (a) random extreme weather events (e.g. hurricanes and tornadoes), (b) the depletion of ecosystem services (e.g. drought and salt water intrusion), and (c) on-going ecological changes caused by the mix of (a) and (b) that have a severe on impact public infrastructure and livelihoods of people. The ecological causes of climigration or clirefuge seeking comprise sea level rise, flooding and drought, which are the three major consequences of climate change stated by the Intergovernmental Panel on Climate Change (IPCC 2007).

About 10.5 per cent of the world's population live in low elevation coastal zones (altitude of less than 10 meters) threatened by rising water levels, higher tides and further-reaching waves; that means some 700 million people, of whom 438 million live in Asia and 246 million in the poorest countries of the world (Piguet 2008). Migration may be the last resort, but it will be a reality to a great many in the near future.

Glaciers all over the world are melting rapidly as temperatures rise. The melting of the Arctic (and less so of the Antarctic) ice cap and permafrost are warming oceans, releasing massive amounts of methane, and will be altering global ocean currents, thereby impacting global climate further. If the Greenland Glaciers melt altogether, sea levels will rise by 7.2 meters and affect one billion people far inland. At present the scenarios exhibit exponential global warming, rather than a new ice age, caused by these ice melts, as the heat of the sun is no more reflected back by ice and snow and the melting waters will warm up and start drying up. And when the Tibetan Plateau Glaciers melt, another billion people are affected, first by floods, then by droughts.

Flooding in population-rich poor countries like Bangladesh and Vietnam's Mekong River Delta as well as coastal cities such as Manila, Guangzhou, Lagos, Ho Chi Minh City, Kolkata, Shanghai, Mumbai, Tianjin, Rangoon and Bangkok (IPCC 2014) will be catastrophic and result in hundreds of millions of clirefugees, if well-planned precautions are not taken. So far these areas have had periodical flooding, and people have evacuated, but they have mostly returned as soon as the water has retreated, with the exception of Bangladesh (Piguet 2008) where a large number of evacuees have become forced clirefugees or climigrants. Once flooding becomes frequent and water does not retreat completely, the inhabitants of other populated areas and cities will suffer the same fate. It is the very poorest, exposed and most vulnerable who cannot leave but will have to stay and eventually perish (cf. IPCC 2014).

Developed countries are not safe, either. New Orleans is still in large parts unpopulated after Hurricane Katrina in 2005 – many of the hundreds of thousands evacuated have not been able to return but have instead become permanent clirefugees (Black *et al.* 2011). Hurricane Sandy in 2012 was another warning of what to expect in the near future: deaths, hundreds of thousands of clirefugees and massive damage in the Caribbean (Bahamas, Cuba, Dominican Republic, Haiti, Jamaica and Puerto Rico) and all along the eastern coasts of Canada and the USA, including lowest-lying parts of New Jersey and New York.

Low-lying cities on any coastline or by any major river are vulnerable to sea level rises, storms, waves and floods, leading to millions of clirefugees. The Thames flooded in February 2014 in Greater London, Middlesex and Surrey, waking up the inhabitants and authorities to the future realities. Low-lying Netherlands, Belgium, and German's Eastern Friesland are better prepared but not secure as the flood effects of climate change increase. As almost 2/3 of the world's population live less than 100 km of the coast and 30 of the 50 largest cities in the world are situated on the coast, sea level rise is a real threat (IOM 2008).

Drought is another mover of the masses. Climate change accelerates droughts leading to food and water crises (Ketola 2011). Ever-more frequent and severe, spreading, longer-lasting and permanent droughts cause water shortages and desertification, shrinking arable land all over the world, from Africa to Asia, Australia, Americas and Europe. Cook *et al.* (2014) calculate that warming climate will subject 30 % of the Earth to drought. This will turn the major agricultural areas of the Great Plains of the USA and a swath of southeastern China into aridity, and spread the dry zones in Central America, the Amazon, southern Africa and Southern Europe farther (Cook *et al.* 2014).

According to IPCC (2007), severe droughts will decrease freshwater availability in large river basins of Central, South, East and Southeast Asia, affecting over billion people by 2050. Already, over the past five decades mass migrations due to droughts have taken place in Africa (Sahel, Ethiopia), South America (Argentine, Brazil), the Middle East (Syria, Iran), Central Asia and Southern Asia (Piguet 2008). Every year hundreds of thousands of rural inhabitants have been displaced in Sahel, with the peak of one million in Niger in 1985 (Hammer 2004, 232–234). Similarly, drought and desertification forced 3.4 million North Eastern Brazilians to migrate during 1960–1980 (Leighton 2006, 47).

Traditionally, Sahel area in Africa suffers from periodical harsh droughts but climate change makes drought permanent and spreads it further north to Arabic countries and south to Southern Africa (IPCC 2014). The East and Horn of Africa already experience exile of five million climate refugees (Afifi *et al.* 2012). Moreover, the latest news in early 2014 report severest ever droughts in Brazil's coffee belt, California, and Australia's New South Wales and Queensland. Grave water shortages are predicted to the Mediterranean, the Middle East, the southern United States and southern China (Schewe *et al.* 2014).

In many developing countries temporal migration is used by some members of households during drought periods as a strategy to improve food security. Case studies in eight countries – Guatemala, Peru, Ghana, Tanzania, Bangladesh, India, Thailand, and Vietnam – show that successful temporal migration of some household members can reduce food insecurity by increasing the available resources to buy food when young, rather educated migrants can send food or cash remittances to other household members (content migration), but unsuccessful migration can exacerbate food insecurity when older, less educated migrants cannot send remittances or food and their absence means reduced labour supply in household for food production (erosive migration) (Afifi *et al.* 2014, Etzold *et al.* 2014, Milan and Ho 2014, Milan and Ruano 2014, Murali and Afifi 2014, Rademacher-Schulz *et al* 2014, Sakdapolrak *et al* 2014, Smith 2014, Warner and Afifi 2014).

Many countries will be able to resettle their climigrants within the boundaries of their nation. This is what the USA is planning to do with the Inupiat, Malemiut, Yupik and other indigenous peoples in Alaska (Bronen 2009), but at least the Inupiat are frustrated by the government who does not negotiate with them to make their migration sustainable by preserving their unique culture and local decision-making (Marino 2009). The three thousand inhabitants of the very low-lying Carteret Islands have been gradually permanently evacuated to other islands of Papua New Guinea ever since 2005 (Piguet 2008). For all Pacific nations, this will be an ever-increasing problem, and will involve relocation of the evacuees as well as the original inhabitants when their resettlement islands start sinking, too, because of sea level rise. This problem will escalate in population rich countries faced by forced migration as poor migrants "cluster in high-density areas that are often highly exposed to flooding and landslides, with these risks increasing with climate change" (IPCC 2014, chapter 12, p. 13).

Climigrants are just as vulnerable as clirefugees, if they are not allowed to decide on their own future. While a great majority of climigration will take place internally within nations, many developing (and some developed) countries will be so holistically overwhelmed by climate change that they cannot provide even for their own unaffected or less affected inhabitants, not to mention their internal climigrants. International migration, or more probably, desperate international refuge seeking, will be the only option.

At our longitude the direction of climate exile is from Africa to Southern Europe, then to Central Europe, and finally to Northern Europe, when drought and water shortage drive the masses further north. In Northern Europe summer drought and extreme winter flooding will alternate because of climate change, but areas still remaining arable will become "the most valuable real estate on the planet, besieged by millions of climate refugees from the south" Ahmed (2010, 58). In North and South America and Asia the development will be more complicated since all three extreme weather phenomena – drought, rising sea water and flooding – interact there massively and simultaneously.

The same applies to Australia: intolerable heat, massive bush fires, droughts and water shortages are spreading from the centre of the continent towards the coastal areas on which the sea water is rising; simultaneously storm floods make the strip of land in between uninhabitable. Australia illustrates in extreme form the exponentially accelerating climate change impacts the whole world is facing (Diamond 2005). It is predicted that Australia will be mostly uninhabitable before 2040 (Kirsch 2010), and the whole population of the Australian continent will have to be evacuated – only the island of Tasmania will be inhabitable in the late 2030s. The current Abbott government's denial of climate change and abolishment of earlier Gillard government's climate package – including an emissions trading scheme with first three years' fixed carbon price, renewable energy target, biodiversity fund, carbon farming futures program and clean technology program – makes mitigation of climate change impacts and planning of climigration impossible. Moreover, the Abbott government's scrapping of the Tasmanian Forests Agreement signed in 2013 under the Gillard government, adding 170,000 hectares to the Tasmanian Wilderness World Heritage Area (Ketola 2013), will lead to intensive logging, which will make Tasmania more vulnerable to climate change effects and will shorten the period this island will be able to inhabit climigrants from mainland Australia. In the long run, most Tasmanian forests will be logged to make room for the arrivals and to make money, which will further accelerate the impacts of climate change and ultimately turn Tasmania uninhabitable. This will leave Australians without any homeland, at the mercy of global community, which will already be overwhelmed by clirefugees from Asia and Africa. The current and previous Australian governments' treatment of boat refugees – indefinite detention, human rights violations, physical and mental violence, relocation to poor, unstable countries and intentional creation of total hopelessness among the refugees – may make other countries reluctant to take Australian climigrants or clirefugees. "Treat others the way you would like to be treated" is a wise piece of advice in this day and age.

Responsible governments would start looking for more land elsewhere and negotiate on its purchase or lease. The Maldives is already saving all its tourist revenues for the purchase of a new homeland (Ramesh 2008). Tuvalu, on the hand, has a bilateral migration agreement on an annual quota of immigrants with New Zealand called the Pacific Access Category (PAC), but this does not refer to climate change or state any responsibility for the displacement of Tuvaluans (Sgro 2009).

Bigger nations have bigger problems, but any developed country can afford to plan organized climate change immigration, if they do not deny its need. Conversely, most inhabitants of developing countries will be left to their own devices, and these billions of refugees will cause a global chaos, if the global community does not acknowledge the situation and start cooperating to adapt to the human consequences of climate change.

Climigration Types

Bronen (2009, 68) maintains that there are three patters of climate-induced migration: "the migration of individuals and households where climate change is one of several factors causing migration, mass migration where entire communities are forced to temporarily evacuate, and mass migration where entire communities are forced to permanently relocate". In reality, the tapestry of climigration is more varied than that. Climate change often interweaves ecological, political, economic and social factors. Moreover, in addition to temporary evacuation and permanent relocation, there is intermediary longer-term climigration taking place. And temporary, longer-term or permanent climigration may sweep away not only individuals and communities, but also the population of larger entities, such as towns, cities and metropolises as well as whole nations of different sizes.

In figure 1 I am drafting an outline of climigration types according to the length of climigration and the number of climigrants, and organize the cases mentioned above as examples for the different types. Climigration can be roughly divided into temporary (short-term), longer-term and permanent climigration (horizontal axis), although the borders between these divisions are vague, and intended one kind of climigration can become another because of changing circumstances. Climigration can also be divided on the basis of the numbers of climigrants involved (vertical axis) ranging from individual members of households to hundreds of millions of people. The two divisions make 24 different types of climigration from temporary climigration of some members of households to send money to other household members (1a) to permanent climigration of large nations (8c). The examples embrace both currently on-going climigration and prospective and possible climigration up to year 2050. For some types there are no examples available.

Number of climigrants	a. Temporary climigration	b. Longer-term climigration	c. Permanent climigration
8. Hundreds of millions	8a. Temporary climigration of large nations	8b. Longer-term climigration of large nations	8c. Permanent climigration of large nations
7. Tens of millions	7a. Temporary climigration of medium-sized nations or metropolises	7b. Longer-term climigration of medium-sized nations or metropolises	7c. Permanent climigration of medium-sized nations or metropolises
6. Millions	6a. Temporary climigration of small nations or cities	6b. Longer-term climigration of small nations or cities	6c. Permanent climigration of small nations or cities
5. Hundreds of thousands	5a. Temporary climigration of tiny nations or towns	5b. Longer-term climigration of tiny nations or towns	5c. Permanent climigration of tiny nations or towns
4. Tens of thousands	4a Temporary climigration of micro-nations or municipalities	4b. Longer-term climigration of micronations or municipalities	4c. Permanent climigration of micro-nations or municipalities
3. Thousands	3a. Temporary climigration of villages	3b. Longer-term climigration of villages	3c. Permanent climigration of villages
2. Hundreds	2a. Temporary climigration of households	2b. Longer-term climigration of households	2c. Permanent climigration of households
1. Tens	1a. Temporary climigration of some members of households to send money to other household members	1b. Longer-term climigration of some members of households to send money to other household members	1c. Permanent climigration of some members of households to send money to other household members

Length of climigration

1a. & 1b. & **prospected 1c., 2a., 2b. & 2c.** Case studies from Guatemala, Peru, Ghana, Tanzania, Bangladesh, India, Thailand, and Vietnam now (Warner and Afifi 2014)
2c. & 3c. Inupiat, Malemiut, Yupik and other indigenous peoples in Alaska now (Bronen 2009, Marino 2009); The Carteret Islanders of Papua New Guinea since 2005 (Egan 2008)
4c. Tuvalu now (Lazrus 2009, Marino 2009, Farbotko and Lazrus 2012, Sgro 2009)
5c. Kiribati and the Maldives now (Ramesh 2008, Randall 2013, Reklev 2014, Schwartz 2013)
5a. & 5b. & prospected 5c. New Orleans, still largely unpopulated after Hurricane Katrina 2005 (Black *et al.*)
6a. & 6b. & **6c.** Sahel area, spreading north and south now; prospect for Brazil's coffee belt, California and Australia's New South Wales & Queensland (IPCC 2014)
6c. East and Horn of Africa now (Afifi *et al.* 2012)
6a. & 6b. & prospected 6c. Bahamas, Cuba, Dominican Republic, Haiti, Jamaica and Puerto Rico, and eastern coasts of Canada & USA, incl. New Jersey and New York (IPCC 2014)
6a. & 6b. & **possible 6c.** Prospect for Greater London, Middlesex and Surrey (EA 2011); prospect for the Netherlands, Belgium and German's Eastern Friesland (IPCC 2014)
7c. Prospect for Australia's mainland (Diamond 2005, Kirsch 2010), Vietnam's Mekong River Delta and coastal metropolises Manila, Guangzhou, Lagos, Ho Chi Minh City, Kolkata, Shanghai, Mumbai, Tianjin, Rangoon and Bangkok (IPCC 2014)
8a. & 8b. parts of coastal Bangladesh now; **8c.** Prospect for Bangladesh (IPCC 2014)
8a. & 8b & 8c. Prospect for the Mediterranean, the Middle East, the southern United States and southern China (Schewe *et al.* 2014), dried-up large river basins of Central, South, East and Southeast Asia (IPCC 2007)

Figure 1.Climigration types according to the length of climigration and the number of climigrants with examples.

The same categorizing can be applied to clirefuge seeking, with the exception of level 1, as it constitutes planned migration of individuals to provide for those staying behind. The other levels 2–8 of clirefuge seeking create an exponentially growing emergency for the departure, transit and arrival countries. To avoid panic and chaos, careful advance planning of climigration is needed between the emigration, intervening and immigration countries – and with the global community in order to share the burden as fairly and equally as possible.

Predicted Climigrant Numbers

In 2007 Christian Aid estimated that there would be one billion environmentally driven migrants between now and 2050 (McNamara 2007). However, since climate change, its impacts and resulting migration are accelerating (Morinière 2009) exponentially, these numbers will become manifold and the problem will exacerbate earlier. Soon billions of people will have to leave their homes on all continents because of rising sea levels, or persistent droughts and water shortages, or unrelenting storms, floods and contaminated water.

A study (Motesharrei *et al* 2014) financed by the NASA gives a prospect that our civilization could collapse because of climate change and population problems, which have been caused by unsustainable exploitation of resources and increasingly unequal distribution of wealth, resulting in water, food and energy shortages that have started to kill the masses (commoners) but have not yet affected the elites who continue business as usual despite the approaching catastrophe until they perish, too. Motesharrei *et al* (2014) point out how civilizations have collapsed in a similar way all along historical times, mentioning the Roman Empire, Minoan and Mycenaean civilizations, many Mesopotamian (Sumerian, Akkadian, Assyrian, Babylonian, Achaemenid, Seleucid, Parthian, Sassanid, Umayyad and Abbasid) Empires, Hittite and Harrapan civilizations, Mauyran and Guta Empires, Khmer Empire, and Zhou, Han, Tang and Song Empires as some examples.

Once again the commoners are the clirefugees who desperately try to survive, but their numbers are growing to mass clirefuge seeking. The elites fend them off their water, food and energy sources domestically and from their so far unaffected countries internationally – until the elites themselves will have to flee in an attempt to survive.

The report of the Intergovernmental Panel on Climate Change (IPCC) (2007) stating that at existing rates of global warming the Earth would be uninhabitable by the end of the 21st century is nowadays considered conservative (Ahmed 2010, Motesharrei et al 2014). As carbon emissions and global warming have only increased since 2007, the end will come much earlier, by mid-century. Ahmed (2010) notes that the evidence from front-line scientific research indicates that the rate of global warming is much faster than the IPCC models predict, making the effects of climate change "to occur far sooner, with greater rapidity, and higher intensity, than officially recognized by governments" (Ahmed 2010, 38), thus hastening the end. Like Motesharrei et al (2014), Ahmed (2010) recognizes this leading to food, energy and water conflicts. The IPCC's (2007) worst-case scenario of 6°C temperature rise, which means the end of life on Earth in our own lifetimes, will be reached earlier and the temperatures will rise far higher than that. Our society cannot support even the soon achieved 3°C-rise conditions, and the 5°C-rise will make all "humans migrate in search of food and try vainly to live like animals off the land" (Ahmed 2010, 35).

Climigration Model

There is plenty of research on the protection of the rights of indigenous peoples (Westra 2009), when they have been forced to migrate because of big business or governments having destroyed their traditional lands, forests and rivers through logging, mining, dam construction and other damaging activities. Climate change migration naturally deteriorates the position of indigenous peoples further both as involuntary recipients of climigrants or clirefugees, when their habitats remain unaffected or are favourably affected by climate change, and as climigrants or clirefugees, when their habitats are badly affected by climate change.

Unexpectedly climigration also introduces a new perspective on indigenous rights: the rights of the original, majority inhabitants of the ordinary villages, municipalities, towns, cities and nations of the destinations of the climigrants. So far migrants have constituted a small minority of the population of their host countries, and even the number of refugees, fleeing in millions from countries like Syria have remained small, maximum 0.1–0.5 per cent of the population in most receiving countries – only in some neighbouring countries, such as Lebanon, refugee numbers have totalled up to 25 per cent of the population. When climate change induced migration or refuge seeking starts in earnest, it will turn the tables: the inhabitants of the countries of destination will become minority groups with the massive numbers of climigrants or clirefugees becoming the majority groups.

Every nation wishes to protect its own citizens. Climigration and clirefuge seeking prompt large and medium-sized developed nations with strong armed forces, such as the United States, the United Kingdom and Australia, to safeguard their borders to prevent such invasion. "Classified studies by the US intelligence community have already red-flagged "regional partners" of the US in key strategic regions in Africa, Central Asia and the Middle East, who are likely to face severe problems, and whose identities remain confidential to avoid diplomatic frictions" (Ahmed 2010, 58). Smaller developed nations with weaker armed forces, like the Nordic countries, which cannot defend themselves against a mass invasion, may have to satisfy themselves with passing laws to protect the land, ownership and human rights of their indigenous population, which they hope the new majority will not abolish. Most developing countries do not have the resources to do either – hence those developing countries least affected by climate change will be conquered by climigrants and clirefugees, inducing conflicts with indigenous populations. This danger is emerging already with the world's first clirefugees on Pacific Islands where relocation from sinking islands onto others' lands has been a sensitive issue, but not yet become a violent conflict (Weir and Virani 2011). Since most of Australia and the UK, and large parts of the USA will eventually also be uninhabitable most of their citizens will migrate to colonialize either those small, developed nations or those developing nations of any size least affected by climate change. Their citizens have the inherited skill to colonialize in their psyche.

The more extreme the global warming with weather extremes and sea level rise becomes the more pronounced will human displacement and migration become (IPCC 2014). The way Ahmed (2010, 35) presents the IPCC's scenarios for global warming by degrees Celsius helps to understand human migration patterns caused by climate change:

1°C increase: Ice-free sea absorbs more heat and accelerates global warming; fresh water lost from a third of the world's surface; low-lying coastlines flooded.

2°C increase: Europeans dying of heatstroke; forests ravaged by fire; stressed plants beginning to emit carbon rather than absorbing it; a third of all species face extinction.

3°C increase: Carbon release from vegetation and soils speeds global warming; death of the Amazon rainforest; super-hurricanes hit coastal cities; starvation in Africa.

4°C increase: Runaway thaw of permafrost makes global warming unstoppable; much of Britain made uninhabitable by severe flooding; Mediterranean region abandoned.

5°C increase: Methane from ocean floor accelerates global warming; ice gone from both poles; humans migrate in search of food and try vainly to live like animals off the land.

6°C increase: Life on Earth ends with apocalyptic storms, flash floods, hydrogen sulphide gas and methane fireballs racing across the globe with the power of atomic bombs; only fungi survive.

At 4°C of warming humans have no choice of whether to stay or leave; they have to migrate to survive (Gemenne 2011, IPCC 2014). At 5°C of warming humans regress to animal-like instinctive migration to meet their basic daily survival needs of food and water.

Piguet (2008) points out that migration research has paid little attention to ecological drivers, and when it has, it has focused on their positive impacts. Historical migration research mentions how the Ice Age made mass migration possible from Siberia to Alaska across the Bering Straits 13,000–16,000 years ago, and how the Medieval Climate Optimum during 800–1400 made navigation easy for migration to Polynesia (Perch-Nielsen 2004, 39 in Piguet 2008, 2). Even the desertification of the Sahara and the Arabian Peninsula after 6000 BC had a positive impact by prompting mass migration to the Nile Valley, thereby contributing to the development of the civilization of ancient Egypt (Hammer 2004, 238 in Piguet 2008, 2).

Crosby (1986) argues that the Europeans colonialized North and South America, Australia and New Zealand and beat the indigenous inhabitants by ecological, rather than military, imperialism: by introducing alien flora and fauna and importing pests and diseases. This may happen again elsewhere. Fagan (2002), on the other hand, reasons that the lesson to be learnt from the Little Ice Age during 1300–1850 is that if we have lots of people living on marginal lands at subsistence level, climate change will cause famine. And while the weakest will perish masses will migrate, if they are allowed to. During the Irish Potato Famine one million people died and another million emigrated from Ireland, mostly to North America (Fagan 2002, Kuparinen 2013). In the tropical world famines 1875–1903 killed an estimated 20–50 million people because of El Niños and colonialism (Fagan 2002).

Modern day historical research on migration after industrialization has been mostly devoid of ecological drivers, as political, economic and social drivers have preoccupied researchers. This does not mean that ecological, or especially climate drivers, have not existed; they just have not been paid attention to. Now in the post-modern, post-industrialization era, ecological, and particularly climate change, effects on humans, their environment and their migration have become acute – this time because of their negative impacts.

The upside of the focus of past historical migration studies on the positive climate impacts is that they may help contemporary generations to turn the negative push factors into positive pull factors, and in this way change unorganized fleeing, clirefuge, into organized resettlement, climigration.

There may be something contemporary societies could learn from traditional nomadic way of life with constant migration (Jónsson 2010, Singh 2012), which reduces the adverse environmental impact on humans – and at the same time reduces the adverse human impact on the environment. It might be possible to develop a novel, 21st century nomadic life style, which could help both the climigrants to find new alternatives and the inhabitants of areas of favourable climate change impacts from being overwhelmed by clirefugees.

Well-managed migration can become a useful instrument for adjustment to climate change, but it should not deteriorate the ecological conditions of the host areas or accelerate climate change further. IPCC (2014, chapter 14, p. 5) stresses that "successful adaptation will depend on our ability to allow and facilitate natural systems to adjust to a changing climate; thus maintaining the ecosystem services upon which all life depends".

Figure 2 builds a climigration model that turns chaotic clirefuge seeking into organized climigration and helpless clirefugees into self-reliant climigrants by learning from history.

Since climate change is accelerating exponentially the model uses partially the future years of climate departures presented by Mora *et al.* (2013) as prompter decades for mass migration for each geographical area. The figure gives examples from Western near history, but all world history migration events from any era can give valuable lessons. Hence the use of this model requires the establishment of a data bank to collect experiences from earlier migrations and refuge seekings caused by whatever reason, in order to learn about successes and failures to plan organized climigration, and coach climigrants to remain self-sufficient, maintain their cultural identity and live sustainably in their new habitats. It would be essential to establish a UN climigration coordination centre in order to prevent people, who have to leave their homes because of climate change, from becoming helpless, vulnerable clirefugees and helping them to become climigrants with initiative, strength and flexibility instead.

(a) Historical migration events (historical facts).

Learning from history…

1500 Mass migration from Europe to North and South America prompted by colonization 1500–1775
Forced slave trade migration from Africa to North and South America 1500–1850
1600 Religious persecution driven migration from Europe to North America 1620–1640
1700 Migration from Britain to Australia and New Zealand prompted by colonization 1788–1930
1800 Forced indentured labourer migration from India and China to British colonies 1830–1917
Mass migration from all parts of Europe to North and South America, Australia and New Zealand 1820–1930
1900 Post-WWII mass migration from Mexico to the USA, from former colonies to Britain and France, from Turkey to Germany, from Yugoslavia and Italy to Germany and France, from Finland to Sweden, from Britain to Australia 1945/50–1970
Illegal and legal migration from Mexico to the USA 1970–
Mostly illegal migration from North Africa to Europe (mainly Spain, Italy, France, Malta, Greece) 1980–
Legal and illegal migration from Eastern Europe to Western Europe 1990–

(b) Climigration: current (2005–), prospected (2015–), evermore likely (2020–) (concluded from the news and Mora et al. 2013).

…turns chaotic clirefuge seeking into organized climigration

2000 Climigration from small Pacific Islands to large Pacific Islands or…? 2005–
Climigration from coastal Bangladesh to inland or…? 2005–
2010 Climigration from Alaskan coast because of sea level rise to inland or…? 2010–
Climigration from coastal, flooded and desertified South Asia (India, Bangladesh, Pakistan) to…? 2015–
2020 Climigration from large Pacific Islands (e.g. Papua New Guinea, Indonesia), Philippines, Malaysia and Singapore to…? 2020–
Climigration from Arabian Peninsula to…? 2020–
Climigration from coastal, flooded and desertified Western Africa to…? 2020–
Climigration from Alaska because of melted ice to mainland USA or Siberia or…? 2020–
2030 Climigration from Northern, Eastern and Southern Africa to…? 2030–
Climigration from Australia to…? 2030–
Climigration from Southern Europe to…? 2030–
Climigration from Mexico and Central America to…? 2030–
2040 Climigration from coastal, flooded and desertified USA and -Canada to…? 2040–
Climigration from Thailand, Vietnam, North East Asia, coastal, flooded and desertified China to…? 2040–
Climigration from coastal, flooded and desertified South America to…? 2040–
2050 Climigration from Central Asia to…? 2040/50–
Climigration from Central Europe to…? 2040/50–
2060 Climigration from Northern Europe to…? 2060–
Climigration from Northern America to…? 2060–
Climigration from North Asia to…? 2060–

Figure 2.Climigration model: from clirefugees to climigrants by learning from history.

Sgro (2009) claims that the European Union (EU) has a better chance to find consensus to the climate change refuge/migration problem than others because both the migration/asylum issue and the climate change issue are high on the EU agenda. She suggests that the EU could create a community status of environmental refugees. Another option Sgro (2009) accepts is the proposal by Biermann and Boas (2007, subsequently 2010) that instead of extending the UNHCR (1951) definition of refugees, a protocol for climate refugees or climate forced migrants should be added to the United Nations Framework Convention on Climate Change (UNFCCC). Sgro's (2009) third option is to create a specifically tailored international convention to recognize environmental asylum.

Whatever the global governance decisions will be, it is clear that comprehensive international cooperation between all countries in the world is crucial. The global community needs to share the burdens caused by global climate change by preventing and assisting during environmental shocks and stresses as well as by opening migration channels (Piguet 2008) for the temporarily, longer-term and permanently displaced clirefugees/climigrants.

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Climate Refugees as Mobile Technology Users in the Future – Scenario-Based Insights on the Challenges and Possibilities

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This preliminary study examines the dynamics and plausible relationships of environmental migration and mobile technology in the future by incorporating some basic methods of futures studies and visioning three scenarios looking 40-50 years ahead. The scenarios tell a story of an urban refugee, a megacity resident and a neonomad, and glance on the different roles mobile technology plays in their lives. The key findings include seeing mobility as a plausible strategy for adaptation in the future, and that some of the basic reasons for using mobile technology today will most likely stay important among the future environmental migrants.

Introduction and Background

This paper is a preliminary study that aims to introduce some insights to the topic of climate refugees as mobile technology users, with the help of three scenarios. The topic of this paper is rooted in discussions with the mobile technology industry on its current challenges and possibilities with mobile devices on refugee camps today[7]. The interesting question that followed was the role of mobile technology in the future refugee situations created by the changing climate.

The purpose of this paper is not to discuss climate change in general, but to understand it as a generating force for population movement. By causing risks and changes, such as extreme weather conditions and resource shortages, to living environments, climate change induces environmental migration. The terms climate migration or climate refugees can also be used when referring to environmental migration or refugees, and there is a discussion on how we should understand these concepts[8]. However, it is not within the realm of this paper, nor its purpose, to discuss these terms more deeply, so I will use them here interchangeably to designate persons:

> *"…who for compelling reasons of sudden or progressive change in the environment that adversely affects their lives or living conditions, are obliged to leave their habitual homes, or choose to do so, either temporarily or permanently, and who move either within their country or abroad."*[9]

Mobile technology is understood here as mobile devices that include hardware, software, operating systems and networks. The actual shapes, sizes and technical solutions of these devices are left under everyone's imagination. This paper focuses on the human aspect of the use of mobile technology, since we are talking about climate refugees, and emphasizes the practical issues, applications and social meanings.

There are many current projects and programmes studying the possibilities of how mobile technology can be used to help to adapt to climate change. They are addressing issues such as weather monitoring[10], disaster res-

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[7] More on mobile decives on refugee camps today: Korenblum (2012); REFUNITE (2014); Beiser (2010).
[8] Morrissey (2012); Laczko & Aghazarm (2009).
[9] Laczko & Aghazarm (2009), 19.

ponse[11] and information on resource shortages[12]. So there are already some understandings about the role of mobile technology in disaster areas, refugee camps and climate change adaptation. However, I was not able to find literature addressing specifically climate or environmental refugees and mobile technology. Even though we are already witnessing environmental migration, it is very much a future phenomenon, and thus holds many interesting questions marks, especially relating to the different uses of mobile technology.

The Process and Futures Table

The process of this small-scale study started by talking with some experts[13] from different fields, such as mobile industry, futures studies, environmental studies, and asking them some of their insights concerning mobile technology, climate change and migration. For many of them, the concept of climate migration was a bit difficult to grasp, but after a short briefing, they were able to narrow down some possibilities and future images.

After consulting these experts and scanning literature and other resources, I defined four main approaches to discuss climate refugees as mobile technology users, and what possibilities and challenges they might have. The first approach is *catastrophic and sudden events* that as the name states, looks at the position of mobile technology in sudden catastrophic situations in our living environment. The second approach is interested in the use of mobile technology and people in *refugee camp-like situations***.** The third approach discusses the relationship between mobile technology, climate migration and *urbanization*. The fourth approach focuses on *mobility*, meaning the mobility of populations and individuals, and its relationship to mobile technology and climate change.

To be able to derive variables from these approaches for my futures table and scenarios, I analysed some macro-environmental factors to understand and describe the framework of key factors relating to the approaches. Just to give an example of the process, some of the factors are illustrated in the Figure 1. To be able to focus more on the futures table and scenarios, I will not elaborate more on this figure and hope that it will be sufficiently self-explanatory to act as an illustration for the purpose of this paper. However, it is important to note that ecological framework creates the boundaries for all the other frameworks, such as the social or economical frameworks.

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[10] Microsoft (2014) FetchClimate.
[11] GSMA (2014) programme for disaster response.
[12] FHI 360 (2014) The climate change adaptation and ICT.
[13] I would like to thank all the experts in different fields who contributed, and my peers, such as collegues from Futures Specialists Helsinki, for their insights.

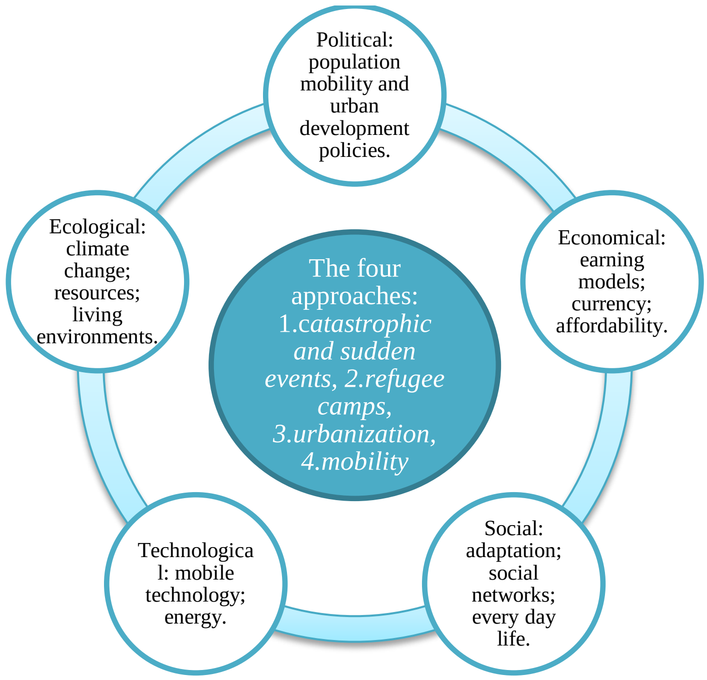

Figure 1. Macro-environmental factors.

Few critical macro-environmental factors and approaches translated then to variables and plausible outcomes into my futures table (Figure 2). I decided on three future images or scenario 'plots' that formed the columns A, B and C. I admit that they could have been a bit bolder, but since the subject at hand is quite complex as it is, I didn't want to complicate things any further. I labelled the 'plots' A and B as bad and good options, because I really could not justifiably say that they are the worst and the best options, which are more commonly used. I made the 'plot' C transformative, because I feel that transformative outcomes always give a bit more room when visioning the future.

When it comes to climate change and humans, it is not that easy to say what exactly would be a good or a bad thing. But I tried to extrapolate the variables 1–5 to outcomes that correlate to 'plots' relatively logically and realize that they are completely subjective. The variable of *mobility policies* does not address questions such as forced and voluntary migration explicitly, but rather provides a broader framework for the freedom of movement. *Climate change* was a tricky variable because there are so many scenarios about the possible outcomes. However, I believe there is a consensus on the matter that status quo will not continue, so I saw the current problems enhanced as a good option. The third variable, *rate of adaption*, is a close relative to political will and resources of the society. The transformative outcome here would basically mean serious action taken already now, in this decade. It is not possible to say that there would be no *technological development*, or that it would be slow. But it is possible to say, that technological innovations that were meant to be good options turn out to be bad options for some unforeseen reason. And it is also possible to say that technological innovations could distribute themselves unequally. *Urban development* was chosen to be a variable, because the trend of urbanization itself is fairly undisputed, so it was more the matter of how well the world handles the urbanization of its population. Will nations be passive or active when concerning the seemingly inevitable urbanization process?

	A) Bad option	B) Good option	C) Transformative
1. Mobility policies	Closed borders, no legal status for climate refugees.	A clear legal framework, policies and status.	Planned migration.
2.Climate change	Melting of the ice coverage, sea level rise, extreme storms, droughts and floods.	Current problems enhanced.	Climate engineering.
3. Rate of adaptation	No capability or ad hoc-adapting.	Risk management.	Mitigating.
4. Technological development	Wrong kind of technology (that was perhaps meant to be sustainable or mitigating) or unequal (not accessible to everyone).	Accessible and useful technology.	Everything is digitalized, cloud services.
5. Urban development	Low urban development, shantytowns.	Well-developed urban areas.	As a form of planned adaptation; Smart cities.

Figure 2. Futures table.

The Scenarios

The scenarios were built value-based[14] with some main leading variables or values. In the first scenario, *Slow Adaptation*, the leading variable was urbanization[15], following the present day understanding of urban migration and the level of urbanization in the future[16]. The title 'slow adaptation' does not refer to the slowness of human kind to adapt, but rather it refers to adaptation to relatively slowly advancing climate change. The second scenario, *Rapid Events*, combines two of the initial approaches: catastrophic and sudden events, and refugee camps. The approach of mobility is the leading feature in the third scenario, *The Mobile Way of Life*, which is also the most transformative of the scenarios.

The scenarios look at past 2050's so the time horizon is at least 40-50 years into the future. Some qualitative values are assumed as standard: a) climate will change and it will induce environmental migration, b) population will grow, c) there will be mobile devices and d) mobile literacy will be higher in the future. The scenarios are general and global in nature and thus do not take into account any regional and cultural specifications. If some cultural or area-specific variables would be added into the mix, the scenarios could actually be seen as plausibly co-existing. The references in the scenarios are both academic and popular in nature, and act as logical connections to the past.

Slow Adaptation (1A-2C-3B-4B-5C)

In this scenario we live in a world with closed borders, which largely restricts the climate migration to national level and to urban migration. However, the migration to urban areas is highly planned and used as a form of adaptation. Large population is easier to maintain in smart cities[17] and in low-risk areas. Those who haven't

[14] The pairs were chosen logically, following the leading variable or approach. The impossible pairs are not presented in this paper.
[15] Which also was one of the initial approaches.
[16] WHO (2014)
[17] Kjaer (2013)

been able to leave rural areas are mostly working in food production plantations, where production environment is engineered to maintain continuous production capacity. Electricity grid is limited to megacity areas and the rural areas are left self-sustained.

This scenario tells a story of a man, who left rural area to live in the megacity. His parents and sisters stayed at hometown and are now working in one of the plantations. He is working in city maintenance, responsible for keeping the streets clean in his quarter. He lives alone in a very small room but contacts his family everyday with his mobile device. His device is one of the finest models, because he uses it at work also, but his family members at the rural area have more modest models, that he sent them from the city. However, everyone's device is able to connect to each other easily. It is important to our hero to be able to stay connected to his family.[18] Luckily, in the village where his family lives, there is a self-sustainable energy grid that provides energy for the mobiles and networks. Also, when our hero has to change locations in the city, for example to extremely traffic dense areas, his mobile device will dynamically change the settings based on network conditions[19] and he can stay connected with his family and friends. This is also important for his work, since he has to report situations from the streets with an application of his mobile device to headquarters, due to the fact that since 2030's the city maintenance was made on-demand based in the smart cities. The city maintenance is also predictive, which is the reason that he gets his working schedules and destinations to his mobile device just in the beginning of his shift.

But when he is not working he likes to tend a small garden on the roof of his building and being a big football fan, watch games from his mobile. He also has pictures of his hometown and family members in his mobile device to keep him company.

Rapid Events (1B-2B-3A-4A-5B)

This scenario tells a story of a young woman living in an urban megacity area. Her city is located in a high-risk area, because it is so old and has a long urban history. She is walking home from work and listening to some music from her mobile, when suddenly she is knocked over by something. While she is trying to get up she sees erupted water pipes spreading water, roads having huge cracks and some electricity poles falling down. Intuitively she starts running for safety up the hills next to her. She is not the only one. Many other people are finding safe grounds as well. On the way she stops to help another woman who has tripped over and is desperately collecting spread items, like wallet and mobile phone that have fallen out of the bag.

When they get on higher grounds they stop to see the devastation behind them. Some helicopter is flying above and announcing something through loud speakers, but she cannot hear it properly. She tries to call her mother to see if she is ok and to find out what is going on. Unfortunately so is everybody else on that hill, and she cannot get through. To make things worse, someone grabs her mobile and starts running away. She is still in shock for what is happening, so she is just frozen, while her phone gets stolen. Someone says that everyone should go to some evacuation centre few miles on the other side of the hill. She starts following other people. She is worried. She doesn't know if something has happened to her mother or how large is the devastation.

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[18] On the meaning of mobiles for urban migrants today Wallis (2013)
[19] NSN (2014)

When she finally arrives to the evacuation centre, she gets into a truck that takes her to the refugee camp. At the destination, her identity is verified and registered with a fingerprint, and she is given a blanket and a bottle of water. The mobile fingerprint identity verification system was under a lot of debate in the 2030's, when it was adopted as a part of population movement policies. Mainly because of many privacy issues. She is starting to recover from the initial shock. She notices that people are getting messages through to family members and asks if she could borrow a device. Se hears that someone is selling them at the camp. She manages to find the guy, who is marketing cheap mobile devices with possibility to use services. She sends a message to her mother and joins in the local mobile network[20] that someone has put up ad hoc. From the local network she gets information on different practical things like that the black market guy also sells spare parts for mobile devices[21] and the toilet paper is out in the eastern sanitation quarters. She also gets updates on the news outside and on what the camp officials are informing. She decides to go for a walk to get some fresh air and to charge[22] her mobile at the same time.

Mobile Way of Life (1C-2A-3B-4C-5B)

In this scenario we live in a digitalized and technologically advanced world that is trying to manage itself in a harsh environment. The sea level rise, extreme weather conditions and in some parts, resource scarcity, has made many parts of the globe very risky areas for human populations. The global community has accepted neonomadity as one of the strategies to survive in a volatile natural environment and in many places moved its populations to low-risk areas. The virtual monetary[23] system replaced the old traditional currencies at the 2030's and transactions are widely made via mobile devices.

This scenario tells a story about a man, who is working in a multinational corporation. He doesn't have a permanent address, because he is constantly on the move. He works solely in the information cloud[24], which also holds in majority of his properties. He utilizes the many living solutions in different destinations that have been created for the neonomads, and which he finds with his mobile device. Sometimes he likes to stay in the small, self-sustained communities[25], where he pays for his upkeep with work or with his special skills. But in megacities, he usually rents a living quarter with virtual currency. He is currently staying in the same country as his brother with his family. His brother is also a neonomad, but a little differently. He and his family live in what is known as a house-on-wheels[26]. They agree to meet in the northern parts of the country, because the weather is turning bad in the south. Our hero is very fond of his brother's kids, who often send him drawings to his mobile device.

When they meet, his brother shows the new application he has on his mobile device, which alerts him on worsening weather conditions and suggests alternative destinations and routes to safer locations with enough resources available. He had chosen this northern meeting point, because he wants to stock up some fresh produce

[20] Ghosekar & Katkar & Ghorpade (2010).
[21] Phonebloks (2014).
[22] Wong (2012).
[23] STT (2014).
[24] Endler (2014).
[25] Guevara-Stone (2014).
[26] Houses on wheels (2014).

from one of the local small farming community that had informed of its surplus. While they go on to get the water and food supplies, the kids pick up their mobile devices and attend their virtual school[27] day.

Discussion and Insights

In this section I first discuss the insights drawn upon the scenario-work and then I shortly evaluate this study generally.

When I first started to look at the questions around this topic, I had the most apparent themes topmost in my mind, such as the problems with charging technology or the weather warnings applications. However, as the process advanced, the meaning of functioning networks and social aspects of technology became highlighted. There can be many insights drawn from the scenarios of this preliminary study. For me, perhaps because as someone having a background in cultural studies, there were three main insights I would like to specifically address here. These insights may not be among the most evident ones, which is also one reason for me to emphasize them. All of them function both as possibilities and challenges.

First of the preliminary insights and one of the key discoveries for me was the **meaning of mobility**. If made technologically, politically, economically and socially possible, mobility can be seen as a plausible strategy for adapting to climate change. Technological solutions, including mobile devices, play an important role for making mobile way of life possible as we can see in the third scenario. The IPCC report states the following: "*Vulnerability is inversely correlated with mobility*"[28]. In other words, the easier it is for you to use mobility as a solution, the less vulnerable you are to disruptions.

Secondly, it seems that **the basics** will endure. What I mean here by basics is the reasons people pick up a mobile device. The basics include staying connected with family and friends, getting access to information and finding entertainment. These are fundamental things in people's lives and already part of the possibilities for migrants today enabled by mobile technology. The basics include also access to resources and help, if needed. Human networking means possibilities, recovering and building blocks for everyday life.

The third insight is **accessibility and operability** and focuses on certain, and quite basic, technological aspects drawn from the scenarios. Alongside the meaning of mobility, this category showcased the learning process that doing futures studies can at best offer. As I stated in the beginning of this section, I initially thought that I perhaps would be writing here about innovative charging technologies or ad hoc applications, which indeed are included in the scenarios. But looking at technology as a point of view of environmental migration and adaptation to climate change, I feel that it is justifiable to emphasize at this point, the importance of working and existing devices and networks. As we saw in the second scenario, mobile devices can be stolen or break. Also, mobile devices need to be able to contact other devices, which requires stable and appropriate networks. These are the things that possibly will always be current issues, no matter what innovative forms the devices may take in the future. Reliable technology is valuable in an unreliable environment.

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[27] Pellissier (2014).
[28] IPCC (2014), p.12.

Before we looked at the skies to predict weather, now we look at our mobiles. There are of course many other possible insights that could and should be drawn from the scenarios for further discussions. For example some insights that should be addressed in the future are the questions of energy, ethics and the fact that people don't use mobile devices in a social vacuum, focusing the examination to more targeted questions. Future energy questions, for example, are very relevant in terms of the highlighted operability of the mobile devices. Future study can also broaden the perspective from displaced individuals to displaced nations and in this way take questions such as the role of mobile technology in nation and identity building under discussion. After all it is very plausible that the sea level rise will threaten some island nations.

The perspective of climate refugees as mobile technology users is an interesting addition to the current study on the possibilities and challenges of mobile technology in changing climate. Being a small-scale introduction to some insights and touching only the surface of environmental migration, this paper leaves out many interesting perspectives and variables. This study also suffers from the lack of expertise on technological issues and perhaps in some aspects from my personal position as a novice in futures studies. However, as I stated earlier, the scenarios offer many interesting insights to readers, in addition to those highlighted here. Also the groundwork made here for the scenarios can function as a starting point for many more intriguing scenarios, which can be drafted for example by changing the value pairs or the variables all together. What I find to be true is that many times the futures studies process itself is more fruitful than the actual reported results.

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Grass-roots Images of Futures about the Global South

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While climate change is a global issue, communities in the global South are hit particularly hard by its impact on their environments. Yet, members from these communities are rarely consulted about the futures that may emerge for them. If civil society actors and developing countries are limited in their engagement in global governance for sustainable development, then members from rural and urban communities in Africa can be considered even more disenfranchised.

Research collaborations that include communities from the global South in the storytelling can form the basis for altering the dynamics of inclusion and exclusion and framing. This paper presents one such collaboration, utilising participatory approaches and methods for the intercultural co-creation of a collection of images of the futures. This futures project, aims for a unique collection of grass roots images of the futures and increased futures literacy among participants.

The Maono project fosters a collection of images of the futures with urban youth and artists in Lubumbashi (Democratic Republic of the Congo). Research and education go hand in hand in this project that involved 81 young adults and 15 artists over the three year project life cycle from 2012 till 2014. This paper argues the relevance of this kind of work, focusing on the characteristics of its participatory, creative, intercultural and collaborative approach.

Introduction and Background

Local impacts of the global phenomenon of climate change are severe. Studies of impacts in Sub Saharan Africa point out reduced water security, loss of agricultural yield and reduced food security, the exacerbation of malnutrition and disease, land loss and decreased biodiversity (AMCEN Secretariat, 2010, p. 1; IPCC report, 2007, 866–871; Yates, Elith et al, 374–391; Hulme, Doherty et al, 152–161). Climate change is also understood as a security threat. Brown, Hammil and McLeman (2007, p. 1141) argue that “climate change is now being recast as a threat to international peace and security; and the region seen as most likely to suffer its worst effects is Africa.” Hendrix and Salehyan (2012, p. 35) additionally demonstrate the relationship in Africa between social conflict and environmental shocks.

O’Brien and Leichenko explain that “assessments of the global and regional impacts of climate change have formed the cornerstone for climate policy debates. Underlying these debates is the recognition that some areas are more vulnerable to climate change than others. Differential impacts superimposed on dissimilar vulnerabilities have resulted in a complex geography of climate change.” (2000, p. 221). The authors propose the concept of “double exposure” as a framework for examining the synergies between impacts of climate change and economic globalization, so highlighting the extreme vulnerability of developing regions.

Africa Portal’s Charles Roger (2013, p .1) states clearly: “African states are likely to be severely affected by climate change and have a major stake in the development of (…) a fair, effective and accountable system of global governance for ensuring climate change mitigation and adaptation.” His analysis focuses on the participation of African delegates in global climate change negotiations.

Similarly, Jessica Green (2004, p. 6) emphasises “the challenge of meaningful inclusion of all stakeholders in the multilateral arena” in her discussion of the types of engagement that civil society actors and countries from the global South have in global governance for sustainable development. Green describes these actors and countries as disenfranchised or "…deprived of the capability to participate and to influence agenda setting and decision making…".

Newell, who studies global environmental inequality, emphasises that this is not just an unhappy concurrence of natural and social geography. He cites Szaz and Meuser to argue that transformations of nature produce human and social impacts that "will fall unevenly, along existing divisions of wealth/poverty; power/powerlessness; the transformations of nature will tend to occur in a way that exacerbates existing social inequalities" (Szaz and Meuser 1997, 111–112, cited by Newell 2005, p. 73)

Newell brings into view the literature of development studies that relates global decision-making processes to their local consequences. This perspective calls attention to elite control of the framings of problems and lack of access for poorer groups (Newell, 2005, p. 73). Together with Green's civil society actors and countries, urban and rural communities in the global South are as good as invisible due to the dynamics of inclusion and exclusion and framing.

Research collaborations that include communities from the global South in the storytelling can play an important role in addressing these imbalances. Knowledge of these communities and the alternative futures they can imagine is an important condition for equitable and appropriate sustainable development thinking and governance. Research that tests participatory approaches for sharing local insight and foresight can provide the basis for learning how to bring members of disadvantaged populations into the sustainability and climate debates. The challenge is to not merely pay lip service to consultation or deliberation but to recognise the rich texture of grassroots images of the futures and to bring these images into the picture, in all their breath and depth and on their own terms.

The project presented in this paper proposes a combination of approaches that opens up and nurtures a collection of grassroots images of the futures in the Democratic Republic of the Congo. The project aims at the intercultural co-creation of images of the futures, engaging young adults and artists in Lubumbashi, the provincial capital of Katanga .

After setting out the project design and processes, the discussion below will focus on the tools and participatory methods used before looking at interculturality and creativity in the project. In this methodological overview the collaboration between partners from different backgrounds is presented as a significant contributor to the successes and failures of the project.

Material and Methods

Maono[29] is an experiment for fostering grassroots images of the futures in the urban agglomeration of Lubumbashi. The project serves a range of research, education and artistic objectives in a North-South collaboration that brings together partners from distinct backgrounds (NGO's, universities, arts and cultural centres,…). Collaborative, participatory, intercultural and creative approaches are combined in a small scale but ambitious qualitative research project. The yearly project cycle started with calls for candidates and participant selection.

[29] Maono translates from Swahili as 'visions'

Then followed 5 days of preparatory workshops and the first recorded futures conversations and preparatory missions before the three week exchange period in Katanga. A programme of activities (visits to businesses, political institutions, the university campus, local NGO's) formed the background to the participants' exchange and search for images of the futures with 21 missions bundled in a Roadbook. In the last of the three weeks, the young participants worked in small groups with artists from different disciplines based in Lubumbashi to create an artistic and communicative image of the future. After the exchange period the participants (as well as project organisers) take up the responsibility of sharing the images and ideas from their Roadbooks and the works created by the artists in their own communities (in coursework, in clubs or associations, in the media and at all sorts of suitable events and occasions).

Participants

Over the course of three years of project activity 41 young adults and 15 artists based in Katanga and 40 young adults from Brussels worked together to observe, collect and create images of the futures. Each year a new groups of young adults took part but follow up with earlier participants also took place to provide continuity and place the work done in each yearly edition in the context of the larger collection of images of the futures the project brought together over the whole three years. The table below provides an overview of the participation in each of the project years. The youngest participant was 18 years old and the two most mature participants were over 30 although the project was intended for adult participants under 26.

	Lubumbashi Youth M – F	**Brussels Youth M – F**	**Rural Youth M – F**	**Artists M – F**
02012	3–7	5–10	4–2	4–2
02013	5–9	7–7	0	4–2
02014	5–6	5–6	0	3–2
TOTAL	**35**	**40**	**6**	**15**

In the first year, 6 young adults from the rural village of Bunkeya were included among the participants from Katanga. The preparation time available to integrate these youngsters into the project and their actual time in the exchange however was more limited than that for the participants from Brussels or Lubumbashi. Consequently they were only able to make limited contributions to the final collection of images of the futures. In the second year no work took place with participants from outside of Lubumbashi. Security and budgetary issues put further constraints on the preparation time and conditions for the exchange. This eventually led to dropping the rural activities of the Maono programme that year. In the final year, the youngsters from Lubumbashi and Brussels did spend a week in the rural village of Kapolowe where they continued their activities for collecting and creating images of the futures together, but no rural participants (other than as host families) were included in the project.

Half of all the participants from Lubumbashi were students of the University of Lubumbashi, another quarter studied at other higher education institutions and with a few exceptions the remaining quarter had a year or more of higher education behind them. It is fair to assume that working with the most severely disadvantaged members of the population of the provincial capital, would have lead to an all-together different picture of personal, local and global aspirations and images of the futures than is presently the case. Their formal education places the participating Congolese young urban adults, firmly in the category of the Congolese middle classes. Only an estimated 300.000 people, study at higher education institutions in the DR Congo (VLIR-UOS, 2011). There are no statistics available on the percentage of tertiary diploma holders in the country but it is safe to say that those who do obtain such a diploma, although not assured of employment or others means towards a secure income, constitute an advantaged layer of the population. Nevertheless, the backgrounds of the participants from Lubumbashi are varied. They live in student dorms or with members of their (extended) families; some of the girls are the head of their household. Several among the participants have come to Lubumbashi from the national capital Kinshasa and others from villages in Katanga and other provinces. The context of the daily lives of the Congolese Maono participants is reflected in the DR Congo's one-but-last ranking in the UNDP's Human Development Index (UNDP 2013, p. 143–145).

The academic experience of participants provides a good base to build futures literacy upon. As young aspiring intellectuals, along the line they can become respected gatekeepers and advocates for their communities. For Maono they are potential bridges to the under-privileged in their society. They can have conversations impossible for the project collaborators from Belgium, about local or thematic futures with grandmothers and street children, with village farmers and fishermen, with street vendors and neighbourhood activists and they can add what they learn from these exchanges to their collection of images of the futures. For the participants it is equally important that the project team is a potential bridge for access to otherwise closed-of arena's (such as the provincial assembly, faculty deans, successful businessmen, media outlets or ministers). Here too the young adults from Lubumbashi find images of the futures that are important to them.

Tools

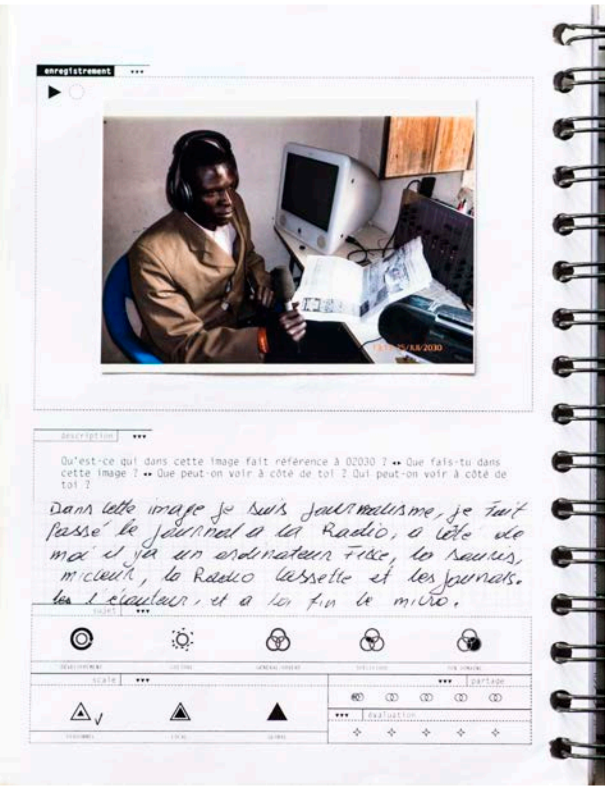
The aim with Maono was not to observe from a distance what images of the futures the three different groups of participants hold. The project set out explicitly to challenge the participants to formulate and envision original images of the futures and to learn about different ways to ask questions about futures. The two project collaborators of Agence Future (AF) accompany this process and provide tools, processes and working methods as well as a safe and open creative, intellectual and social space for the exploration and exchange.

The primary tool offered to the young adult participants is a "Roadbook" that contains 21 missions for exploring alternative futures. Each mission explores possible futures from a different perspective and each mission is only complete with an image. That image can be a photo, a video-still, a clipping, collage or drawing and even sound recordings have been made. [30]The participants from Brussels used their own photo- video- or audio recording equipment and for the participants from Lubumbashi there were 7 small digital photo camera's with video-recording functions and two audio recorders. A library-like system for keeping track of the camera's and the images on them was worked out which coincidently helped to cast the camera as a desirable and relatively scarce resource to be used with care. On the whole of the three years only one of the camera's got lost, none were broken.

The missions in the Roadbook fall into six broad categories: orientation, observation, construction, combination, conversation and navigation. More than a third of the missions set the task of holding a semi-structured

[30] download a pdf of the full 204 page Roadbook here: http://www.wfsf.org/resources/pedagogical-resources/workbooks-from-futures-courses/54-ktng-mo14-rbnl-binder/file

conversation about the future. The time horizon used for all of the missions and for the questions in the interviews is 18 years from the present (2030, 2031 and 2032). For comparison with longer timeframes a horizon of 81 years is also used. In the introductions and preparations with participants these time horizon's are compared with the time it takes for a new born to grow into an adult (18 years) and with a lifetime (81 years). For the conversation missions the question schedule starts with an open introductory question, then personal futures are discussed (ideal, worst case, expectations), local futures (idem), global futures (idem) and the conversation is closed with two questions for the imagination. The first of these challenges the respondent with a question about the extreme long term. Interviewers are encouraged to decide on the time horizon of this questions based on the conversation partner's ease with the 18 and 81 – year time horizons of the preceding questions. It can be a thousand years, 500 years, a century or less, the idea is to make it sound so far away, that logic used for previous questions does not have to apply. The second question for the imagination is an interview version of the Mission #05 "Glimpses". It asks where we might already see an example of what a future could look like, where in the present we can perceive some aspect of a future world. Participants learn specific interview techniques and are encouraged to rephrase the proposed questions and add their own prompting for the treatment of specific topics or perspectives. The first conversation is held with another participant (a practice run and a way to discover each others outlooks). The next conversations entitled "My family" and "My place" take place in familiar surroundings. Then participants are ready for specialised conversations (about a theme, an organisation or a specific activity) and for conversations "elsewhere". To close the experience off, participants once again interview another participant and agree on a meeting place and time some time in the future.



Participatory approach

Voluntary NGO's working at the grassroots level, have advocated participatory research for development projects for decades (Davis, 1998, p. 74). Some approaches such as community based participatory research in public health disciplines as well as Participatory Rural Appraisal and Rapid Rural Apraisal have become popular diagnostic and assessment tools as "many DO (Development Organizations) engage in field research before, during and after the implementation of projects in order to identify the needs, assess progress and determine impacts." (Moseley, p. 336)

Because of the direct relationship with the development projects that participants or their communities stand to gain from, the implications of participation in this kind of work are dissimilar to participation for research purposes only and even more so for participation in explorations of the futures or foresight programmes. With futures projects such as Maono, the participants' visions of the futures may play a part in change processes, but there is no promise of any material impacts.

Da Costa (2010, p. 502) points out that some years ago conventional development organisations claimed a shift in development practice towards seeking to listen, away from seeking to tell. With Maono we ask to share images of the futures, we listen (and look even more) but we also tell (discuss) how these images could come into being and we support that process. There is little removed distance between the participants or their images as subjects and the project collaborators (who run the project but also take part in it). Facilitating the participants' and artists' explorations, the collaborators are in fact engaged in participatory observation of a process they themselves instigated. This entangledness makes it all the more important for the collaborators to be aware of their own perspectives and potential impact on the participants and the collection of images they bring together.

I am an academic futures researcher and private consultant. Together with my life partner, photographer Bram Goots, I run a small non-profit organisation engaged in participatory futures projects. Bram and I worked together closely on the Maono project. Three years in a row we travelled to Lubumbashi as volunteers to accompany the exploration and the exchange there. My outlook is at the same time one of a teacher/guide (share futures studies techniques and theories and accompany an exploration of images of the futures) and one of a researcher (observe attitudes, ideas, processes and behaviours, ask critical questions about image making and creative processes and the content of the collection). The two roles are not separate, we learn how the young adults and artists think about futures, from the questions they ask and points they raise in group discussions and individual exchanges as well as from the tangible images they produce. We accompany the selection process of the images for the overall collection by asking of every image to be printed as a photo for a Roadbook mission, how and why this image answers the question of the mission in case. We follow the collaboration between the young adults and the artists closely and sometimes influence the direction they take together (when the artist and the participants have different ideas about what should be made, we help them negotiate for instance). All along we seek to bring useful futures literacy to everyone involved.[31]

[31] Being in the DRC for teaching something so intangible as foresight to a mostly eager audience that is supposed to multiply the ideas brought forward, the problem of "evangelisation" unavoidably creeps up in the author's mind. I am a Belgian and nowhere else in the world is that of any particular importance (not even in

Given that at every stage of the process, we listen and tell, it is important that not just we ourselves but even more so the participants, understand our motivations for running/taking part in the project. That our own previous work resembles closely (is the basis for) what Maono participants are asked to do with their Roadbook missions, helps clarify our position: we are professionals who have experience with recording futures conversations and with collecting and creating images of the futures as well as critically analysing them. The participants contribute to our practice and collection of images of the futures. We teach them about futures studies, we accompany them in their own exploration and together with them we practice foresight and foster a collection of images of the futures.

For the participants the project clearly has a lot more to offer than futures literacy and a collection of images of the futures.[32] The students from Brussels get cheap travel to a country on another continent with professional organisation[33]. The young adults from both cities welcome the chance to meet each other and learn about each other's lives. A programme of visits opens up otherwise inaccessible places to them. The participants from Lubumbashi in particular valued access to Europeans (with the potential of building lasting relationships) and to public and private spaces of power. For the artists the project offers networking possibilities, a challenging theme, a new process (co-creation) and a working budget. For many of them, the possibility that their work will be shown at cultural venues in Europe and even that they themselves might eventually travel to present their work is highly significant. The collaborators' role in these matters is to provide real clarity about what is part of the project set-up (for the artists an exhibition as closing event in Lubumbashi and in Brussels), what commitments we make (concerning locations, publication, promotion or contacts for instance) and what the range of possible outcomes is. In the intercultural setting of this project, the expectations of all those involved need to be taken into account and common expectations are only built with time and care. In any case, the terms of engagement need to be understood and supported by everyone.

The creation of a collection of images of the futures in Katanga is a joint project by the organisers, collaborators, young adults, the artists and even their networks, in that sense the participation in Maono is genuine.

Images and creation

A collaboration with 12 to 18 artists in Lubumbashi was central to the project design. Over the course of the three years we worked with artists from ten different disciplines: painting, literature, sculpture, drawing, choreography, music, conceptual art, photography, video and graphic design. Prior to implementation it was determined that one third of the artists had to be women (two out of six every year). We found and selected the

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Belgium) but in the DR Congo it is often given special importance because of colonial history. The missionary record of Belgians before us has been cause to pause for some soul searching. While we remain critical of our role as teachers, we have come to the conclusion that our position is actually nothing like that of the nuns and priests that affected Congolese history so much as representatives of such a powerful institution as the Catholic church. The hesitant recognition of our topic in academia, the marginality of our subject area in vestiges of power of the global North and its potential for contestation and subversion, lead us to conclude that we are not actually in the business of conversion reproducing pre-existing relations of power.

[32] Debriefing notes from group

[33] provided by Universitair Centrum voor Ontwikkelingssamenwerking, the development education partner NGO in Brussels with close ties to the Brussels University Association

artists with the help of the arts centre Picha who also made their premises available for meetings and work with the artists.

The artists were briefed by the Agence Future team and prepared their collaboration with the young adults by identifying future related themes in their own work and developing a proposal for a creation for Maono. Each year some established local names were included in the group of artists (Sando Marteau, who is a griot, actor and singer or Jean Katambayi and Georges Senga who have been invited to several African as well as European arts festivals). There were important differences in the way the experienced artists organised the collaboration with the young students and the approach of debutantes like video maker Judith Kalanga and graphic designer Alain Nsenga. The younger artists had to negotiate more with the young adults about the images to bring forward and sought more support for the practical organisation of their creation process. Artists with a larger portfolio were able to identify suitable links between the futures theme and their own work with more ease than young artists who have not produced as much yet.

Each year the collaboration with one of the six artists was repeated. The comic strip maker Daniel Sixte Kakinda developed a second part to his comic strip after the exchange period of 2012. In 2013 he drew four big black and white drawings with four futures scenarios for mining. In 2014 we continue d the collaboration with conceptual artist Jean Katambayi who has worked intensely on the development and build of his fictional machines that defy the laws of nature to settle unbalances in the world. After the three years 15 artists produced 17 unique images of the futures in the framework of the project. [34]

The young adults in the project take on as their main challenge, to pay attention to images of the futures and make up their own. The requirement of providing concrete images for each of the Roadbook missions, for most of them means a switch from abstract or narrative thinking to visual thinking in addition to the switch from present-day thinking to long-term visioning. Finding and making images is an uncommon method, a new form of discourse to them. This takes them out of their routine and encourages them to think 'differently'. Having to create a picture accompanied by text each time engages their creativity. 'Picturing' futures, brings these futures closer and makes them more real. The shared image based work helps them to 'see' what their fellow participants mean and not to stay stuck with abstract generalisations concerning future possibilities.

For the participating artists on the other hand, translating ideas into concrete images is everyday business. They are already involved in reshaping reality into sights and sounds, creating different forms and innovative ways of seeing. The artists take part in the project as professional makers and bring their expressive and communicative skills into the mix. Their challenge with Maono is to include the ideas, feelings and preferences of the young participants in their creation process. By not just taking inspiration from them but also involving them in the artistic creation, the artists help the participants practice the visual approach Maono proposes. They aim to produce images (works of art) that have a strong communicative value. This improves the potential for effective visibility of the whole collection of images created in the project.

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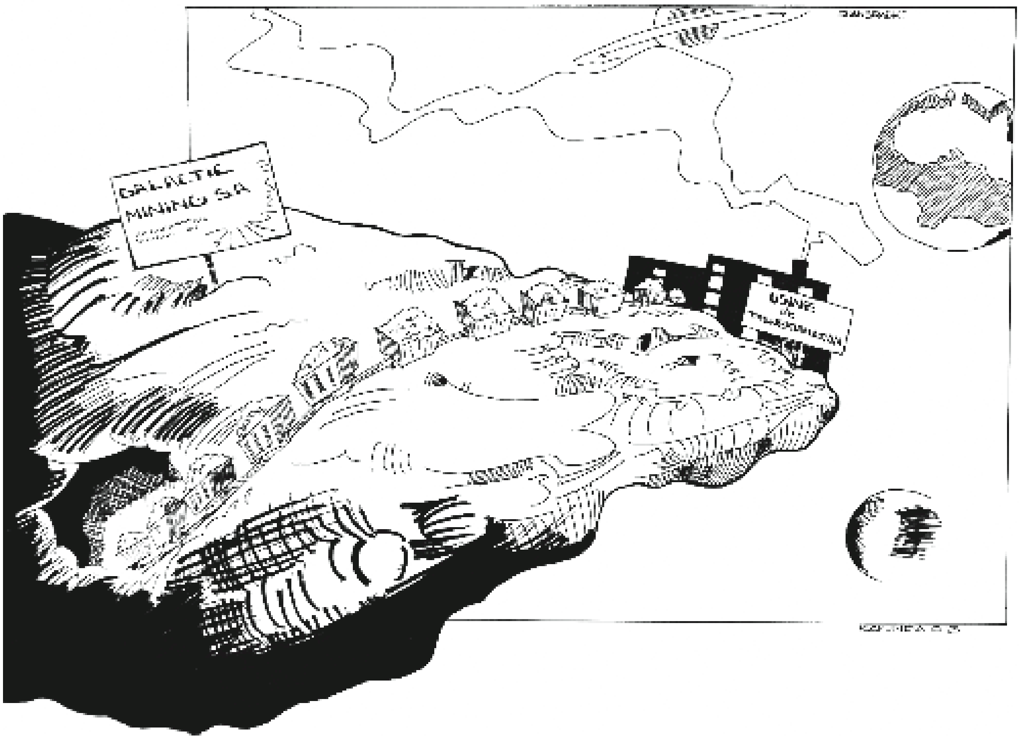
[34] For a complete overview of the portfolio of 17 pieces, refer to: http://www.agencefuture.org/?q=artists-rdc



TRANSFORMATION: Drawing from ‘Scénarios’ series by Lubumbashi based artist Daniel Sixte Kakinda

Interculturality

Offering young adults from the provincial capital of Katanga an exchange with a group of their peers from Brussels and a group of artists, the project set-up is explicitly intercultural. This interculturality is intended to help participants put their own views into other perspectives and to bring a natural questioning of the pre-existing assumptions that affect their visions of the futures. The intercultural exchange between the different groups stimulates everyone to make such assumptions explicit and to allow them to be placed alongside completely different, sometimes even contradictory starting points.

A major challenge for the project organisers was not to fall into the trap of inter-culturalism as described by Da Costa (2010, p. 512): “…inter-culturalism was promoted by theorists and artists who saw in symbols, rituals and performances the world over the sub-stratum and possibility of a shared humanity. Yet in practice inter-culturalism has been a mode of cultural exchange through which First World actors engaged in extractive processes of mining other cultures, adding value to the final product by claiming a universal value of Third World ingredients, and distributing the multicultural product through existing structures of inequality.”

The Roadbook by Agence Future proposes three missions[35] for sharing, comparing and combining that bring reflection on interculturality. The principle of a common goal, a shared objective at the end of the road in combination with sufficient time and occasion to build up trust and to find out about each others outlooks, makes the

[35] Missions #10, #11 and #12

intercultural exchange happen in a constructive manner. The partner organisation UCOS, with almost a decade of experience in setting up familiarisation journeys for Belgian students, accompanied the exchange with workshops intended to allow all participants to learn about interculturality. However, the specific approach has not demonstrated its constructiveness. Over the three years the set-up of the workshops varied but it always asked about and showed up difference more than similarity, aimed for 'acceptance' rather than combination and collaboration or shared contestation and was geared at talking with and about each other rather than learning to work together. The workshop sessions lacked facts and knowledge sharing about the material conditions underlying cultural experiences. One particular workshop technique used at regular intervals during the exchange, 'ventilation'[36] divides the young adults up into two distinct groups according to their city (continent) of origin. This slows down the process of facing up to each other's experience and interpretations by legitimising the impulse to share thoughts about the other only with those similar to oneself. At moments of misunderstanding or mistrust, this approach brought the wish to be better understood by the other or to change the others mind, rather than the desire to adapt ones own perspective or fundamentally contest the basis of the unshared views and experiences.

This kind of inter-culturalism can be seen as "a product of structures of state multicultural policies, global inequalities and intra-cultural hierarchies even as its goal is to transcend these relations and histories." (Da Costa 2010, p. 512) Even so, the shared work on images of the futures did at times stimulate participants from all three groups to look beyond difference and put forward creative subversions of the present.

Collaborative set up

The above comments on the approach to interculturality already revealed that the partners in the project have not always shared outlooks or stood behind each others working methods. These differences are due to previous experience, working habits and the overall goals and objectives of the organisations, factors that are difficult to change over the course of a demanding project implementation. Nevertheless, this kind of collaboration between partners with divergent backgrounds from the global North and the global South has important advantages for all involved.

Each partner has their own domain of expertise: the cultural centre Picha knows the cultural scene of Lubumbashi inside out (but is undermanned and lacks logistical organisation); Etoile du Sud a thematic focus on health rights and strong ties in popular neighbourhoods of Lubumbashi (but lacks influence and means for its activities); UCOS has experience setting up travel-programmes and has access to persons and institutions of influence in Lubumbashi (but does not take a comprehensive view of the project themes and is not deeply engaged despite being the largest partner in the project and holding the budget); the World Futures Studies Federation (WFSF) is specialised in futures literacy (but has no local knowledge and is involved only through the in-

[36] A group process in which participants discuss their best and worst experiences following the principle of basic brainstorming that none of the ideas related can be criticised or commented upon.

volvement of one of its members[37]); AF has worked around tangible images of the futures for more than a decade (but is not established as an NGO).

Despite the difficulties encountered during the collaboration, most evidently between the two European initiative taking partners UCOS and AF, without the combination of competences, networks, experiences and objectives, a broad project such as Maono could never even take place. As Mosely (2007, p. 336) suggests, it is important that development organisations (NGO, governmental or multilateral), academics and local communities collaborate with each other. It is even fair to say that working well with members of local communities is preferably organised this way, with more than one partner[38] to balance out the objectives and to ensure the multi-dimensionality of the play of power in the project.

Results

As the third year of exchange and exploration has only just come to a close at the time of writing, the project results that can presently be discussed are still very broad. The quantification of the collection, the presentation and analysis of the actual images in the collection and conclusions about the futures orientations of those involved in the project, will be brought together in the final six months of the project cycle.

The collection of images

At this point we have collected almost 5 TB of digital data (photo's and video's from the participants and the collaborators) as well as 15 works of art. They provide an unusual (if not subversive) look at African futures that goes far beyond the usual staple of NGO dominated and often-negative imagery about the continent. Our collection includes a comic strip about water-mining in Katanga in the year 2032, a machine to balance out the inequalities between North and South by adding a third rotation to the earths spin and path, a first-person video narration about the longevity of plastic, a happy tune about human unity, etc. There are more than fifty self-portraits of young Africans and Europeans projecting who they will be in 18 years time. There are images of the things to take along to the futures and of how the future is depicted in the public space of Lubumbashi. There are images of fish and of banana's, of children and families, of modern construction sites and houses pulled up out of mud, of bicycles and busses, roads too and even more of people. These images have a definite use value (for those that have made them as well as those they reach) and a series of publications, exhibitions and events is intended to open up the entire collection.

The intangibles of process

As with any successful foresight programme, the results are also in the process itself. Those involved in the project have benefited from spending time and learning together and looking at questions that had previously never been on the agenda. Those involved have extended their peer community (to include others whose futures are at stake) as well as extended the facts available to them (Bidwell, 2009, p. 748) Moreover, practice

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[37] The author is a member of the WFSF executive board and runs their UNESCO Participation Programme Project World Futures Learning Lab (LEALA). Maono is one of the three LEALA pilots (the two others being in Cairo and Penang).

[38] We add local and international private bussinesses to Moselys three types of potential partners,

with intercultural exchange (the only way to learn it) has changed their experience of the world and their own place in it.

Futures literacy

Among the envisioned results is the take up of ideas and methods from the domain of foresight by those involved in the project. Such futures literacy goes beyond mere theoretical understanding of Futures Studies and includes attitudinal and behavioural change. Self-reporting of participants from the first two years of the project shows that the exchange has had a definitive impact on their outlooks and has so to speak ignited the future fuze in many of them. Participants have gained knowledge and most testify they have changed their attitudes (towards the futures) and adapted their orientation for action in the present.

Evaluation of methods

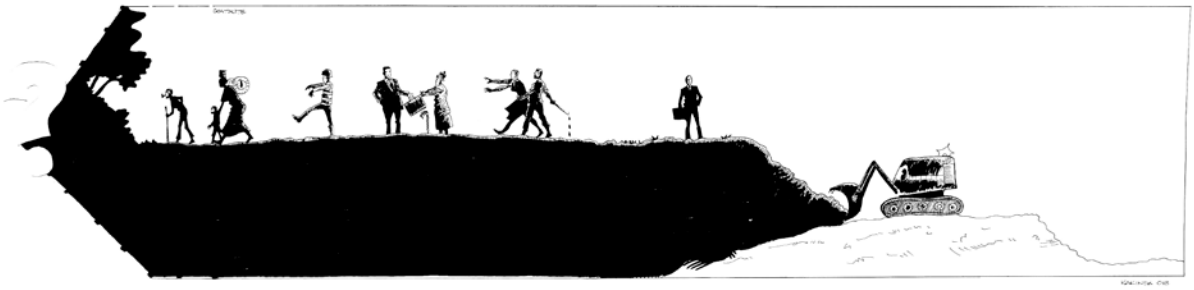
The evaluation of participatory, intercultural, creative and image-based methods for foresight programmes and their applicability in the global South is a result of continuous monitoring and redefinition of the best ways to achieve the project objectives during the project life-cycle.

Discussion and Conclusions

From the direct effects of changing rainfall patterns to the heightened risk of social conflict or (civil) war, communities in the global South meet the consequences of climate change. Futures oriented methods can undermine the present day dynamics of exclusion and inclusion which to place these same communities firmly outside of the global sustainability debate. This paper has presented a participatory, creative and intercultural approach to advance the inclusion of otherwise ignored stakeholders. Taylor made qualitative work such as undertaken with Maono, can provide genuine openings for these stakeholders to work out their positions towards the futures that might emerge for them and to effectively share and defend their ideas concerning these futures.

Chilvers (2008, p. 155) warns that "effective participatory appraisal under uncertainty needs to guard against the 'technocracy of participation' by opening up to diversity, difference, antagonism, and uncertainties/indeterminacies." To this end a high degree of customisation is needed. Maono shows that such an approach is feasible. Proposing a complex project agenda to members of communities in the South and involving them in adapting and concretising that agenda and in making it happen, we have been able to work with alternative epistemologies as resources and sites of possibility as suggested by Da Costa (2010).

The missions in the Maono Roadbook stimulate observation, analysis, creativity and critical reflection and the special ingredient of image making and the collaboration with the artists has been fruitful. This kind of participatory community futures projects in the global South is preferably developed and implemented with a diverse range of partners, not just from both hemispheres but also from different spheres of activity. With enough time and a reiterative project cycle, open research questions and mixed objectives can evolve to enrich the results in unexpected ways. All these elements count and require a great deal of care and attention, maybe that is why in this project I have crossed an important personal cultural boundary and have accepted the role of "Maman Maono".



CONTINUATION: Drawing from 'Scénarios' series by Lubumbashi based artist Daniel Sixte Kakinda

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On Becoming a Disciple of the Disciplines: How Development of Learning Organisation Capabilities Supports Organisational Sustainability

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Managing change successfully is arguably challenging for organisations today. Whilst many rise successfully to meet this challenge, the speed of change adds to an already extremely complex area. Therefore, developing learning organisation capabilities may help cope with this change thus ensuring development of organisational sustainability. This paper explores ways of developing those capabilities and reports on an empirical study done with a Finnish learning consultancy. Drawing on the principles of action research, the study was conducted with employees using three instruments: a survey and semi-structured interviews and reflection journals. By using a social constructivist approach to grounded theory, a model for organisational sustainability was developed. This paper argues that ongoing exploration of mental models is vital with reflexivity playing a key role in developing organisational sustainability. Although action research is a highly contextualized approach and the conclusions reached may not be applicable to others it is hoped that the practical model of inquiry developed to conduct and implement an action research investigation may be of use.

Introduction

Managing change successfully is arguably one of the most challenging aspects of running an organisation. Whilst many organisations rise successfully to meet this challenge, the sheer speed at which this change occurs, adds to the already complex area that change management encompasses. According to Senge (2006:4) 'the organizations that will truly excel in the future will be the organizations that discover how to tap people's commitment and capacity to learn at all levels in an organization'. He holds that if an organisation is to survive and remain sustainable, then it is insufficient to have only the leader in the driving seat. They must be prepared to let their people co- navigate in order to help drive the organisation across the winning line and onto the podium; in other words, to become a learning organization (Senge, 2006:3). Defining a learning organisation and its potential for development are challenging tasks. However, a possible starting point may lie in our approach to responding to change. Indeed, the change management menu is an extensive one with leading management theorists offering a veritable banquet of models and theories on how organisations can best respond to change, for example planning and implementing change (Lewin 1951; Kotter 1995) the stages or phases of change, (Lewin 1951; Kotter 1995) in addition to analysing change at any given moment (Lewin 1951; Beckhard and Harris 1987). In contrast there are theorists whose tastes lean more towards a sustainable and holistic view of change (Bridges 1991; Argyris 1999; Pedlar et al 1991; Senge 2006). Of particular interest is Senge's model of systems thinking and his views on the Learning organisation. According to Senge many diverse types of systems exist; '…corporate, urban, regional, economic, political, ecological and even physiological systems' and he encourages us to try and see connections when dealing with 'challenging managerial issues' (Senge 2006:66–69). His argument supports thinking in terms of the bigger picture as opposed to a single narrow isolated view; in other words, to see our world in terms of interaction as opposed to isolation (ibid). He illustrates this with the story of three blind men, who, upon touching an elephant, develop their own isolated, mental image. Their blindness prevents them from seeing the animal in its entirety. It is this blindness which may lead to one of his seven learning disabilities and he offers what we may call his therapy in the form of the five disciplines; systems thinking, personal mastery, mental models, shared vision and team learning (Senge 2006:129–252). Each discipline comprises of a set of principles and certain practices we can apply in order to master the disciplines. In addition, he gives us a 'set of specific tools and techniques' in the form of 'reinforcing, balancing and delay feedback' and refers to these as the 'building blocks of systems thinking' (Senge 2006:68–79). They are present in his 'system archetypes' or in other words, repetitive behavioural patterns (Senge 2006:93). Improving these patterns requires identifying the 'leverage' or '…small, well focused actions that can sometimes produce significant, enduring improvements' (Senge 2006:64). This is presented in figure 1 below.

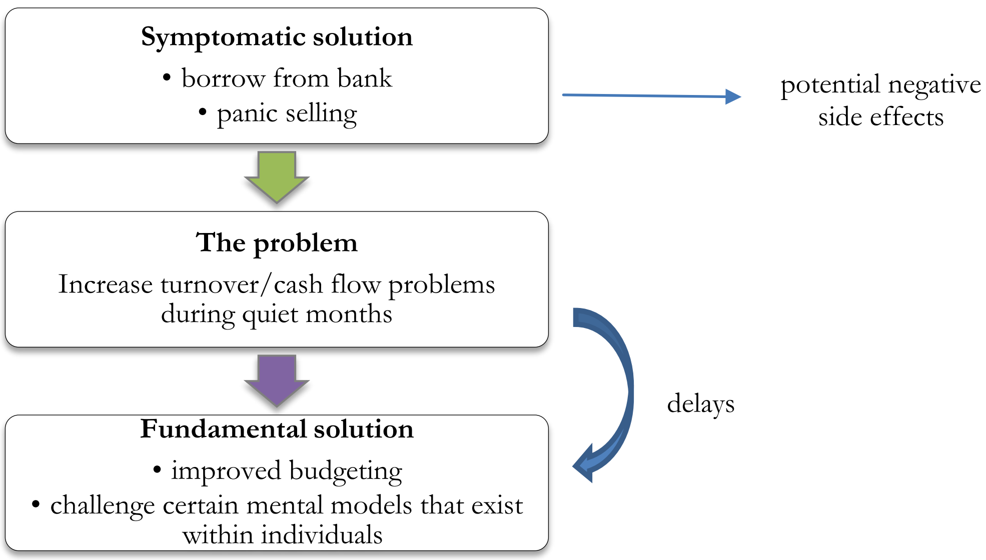

Figure 1. Shifting the Burden: based on a diagram in Senge (2006) p. 392.

Senge believes that the potential exists for organisations to change and states that 'learning organizations are possible because, deep down, we are all learners'. He defines the learning organisation as a place ' where people continually expand their capacity to create the results they truly desire, where new and expansive patterns of thinking are nurtured, where collective aspiration is set free, and where people are continually learning how to learn together' (Senge 2006:3). However, behind this rather optimistic and upbeat statement lurks a dark and destructive force. Human beings, and by connection organisations, are experts at using what Argyris calls 'defensive reasoning' which can inhibit learning (Argyris 1999:231).

Consequently, the ability to look inward, or as Sinclair and Wilson (2002:60) articulate, to be 'self focused', has been identified in one shape or another by the literature for its role in creating the leader for the 21st century; an important driver in any learning organisation (Sinclair and Wilson 2002; Argyris 1999; Schön 1991; Kotter 2012). Central to this drive is the role that the qualitative research methodology action research has to play. Specifically, it is viewed as a beneficial change management tool for supporting the development of the learning organisation as it is 'grounded in the context, yet data-based' (Watkins and Golembiewski 1995:97). Reason and Bradbury (2013:1) define action research as 'a family of practices of living inquiry that aims, in a great variety of ways, to link practice and ideas in the service of human flourishing'. Similarly, Elliot (cited in Altrichter et al 1993:4) defines action research as ‘the study of a social situation with a view to improve the quality of action within it’. According to this definition, it would involve identifying an unsatisfactory situation where Burns (2010:2) suggests the next steps would be ‘to intervene in a deliberate way in the problematic situation in order to bring about changes, and, even better, ‘improvements in practice’. This intervention can be approached in number of ways, depending on your chosen discipline, your primary interests and which side of the world you live on (Coghlan and Brannick 2013:44). Marshall et al (2011:27–29) propose it is framed by a number of ‘interlinked dimensions’ which include ‘an inquiring attitude, asking value laden questions, participation and democracy, reflective rationality and is emergent’. Depending on the nature of the research, the action researcher will have a particular focus which can be understood as four quadrants presented diagrammatically below in figure two:

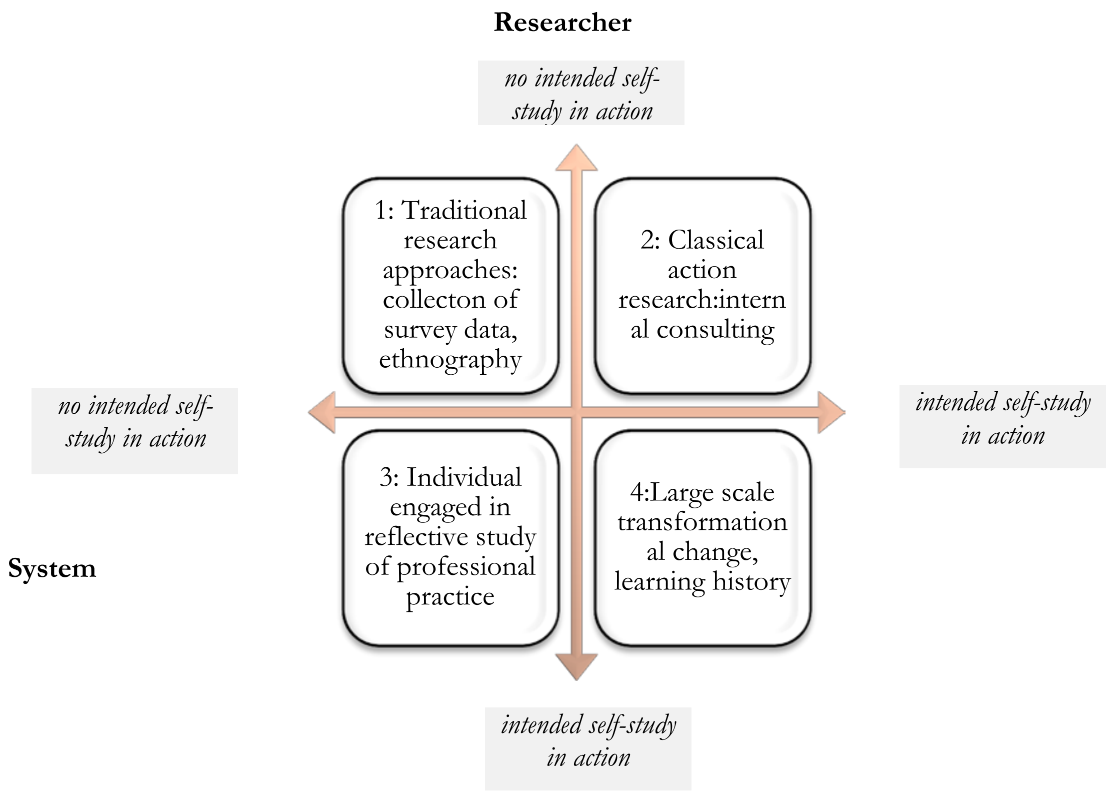

Figure 2. Action Research quadrants: based on a diagram in Coghlan and Brannick (2010) p. 103.

Moreover, there are several advantages for the people involved in the process and the possibility of actually making the changes stick, thereby supporting sustainability from an inside out, bottom up, grass roots approach (Marshall et al 2011). Reason and Bradbury (2013:8) state that ‘action research is rooted in participation, which in turn supports the key values of purpose and practice in action research efforts’. Similarly, Gustavsen (cited in Coghlan and Brannick 2013:35) declares that action research is ‘a network activity, and research therefore needs to follow and move away from a model whereby it is embedded currently in the expertise of isolated individuals operating from a top-down expert model’. It is important to remind ourselves that it is doubtful that we will ever arrive at being a learning organisation as we have embarked on what Senge refers to as a ‘never ending journey’ (Senge 2006:272). It is a journey which will most certainly extract a personal toll on us and he highlights the fact that this ‘is demanding because learning stretches us personally’ (ibid).

Background

The context for this action research study is a Finnish-based consultancy which was established in October 2010. By Mintzberg's (1979) standards it remains a small enterprise and is still in the 'simple structure' phase. Nevertheless, a deeper understanding of how to become a learning organisation is imperative given that it can contribute to the consultancy's sustainability and ultimate survival. Certain challenges have arisen within the consultancy since its inception and critical to this action research was an understanding of these challenges and finding proactive ways of dealing with them. The research questions that guided the study were;

Do we know why becoming a learning organization is desirable for the organization? Will the practical tools that have been developed and implementation enable us to continue developing as a learning organization?

Does reflexivity and reflective practice have clear roles to play in the development of a learning organisation?

The importance of question one lay in cultivating a deeper understanding of the components in order to avoid the risk of 'groping in the dark' as we sought to develop learning organisation capabilities (Senge 2006:5). Question two was significant as by delving deeper into Senge's core five disciplines and system archetypes we looked at ways of identifying leverage from the challenges, working towards what Senge (2006:94) believes can 'make explicit what otherwise is simply 'management judgment'". In addition the importance of these questions were based on the consultancy's mission, values and vision statement which makes the claim of '*being authentic – no matter who is watching'* and to '*monitoring the gap between what we say we do'* versus '*what we do'*. Another important question was 'how can the consultancy communicate the importance of authenticity to our clients if we do not truly understand what it means? Therefore, the role that reflexivity and reflective practice had to play also needed to be examined, hence the importance of question three.

Methods

An action research approach was employed for this study. The sample consisted of four company associates and a total of three instruments were used. Firstly, face to face interviews applied an approach termed as 'retrospective research' (Dörnyei and Taguchi 2010:109). One important element of this approach is open-ended reflection and this was achieved by the second instrument; a survey which consisted of five categories and thirty seven statements, ranked according to the criteria of very important, important, not very important and unimportant.

Furthermore, in order to attain triangulation and meet the appropriate first person researcher criteria, the third instrument consisted of personal MSc journal reflections. Although qualitative research is primarily analysed from a subjective perspective, the data analysis attempted to refrain from any personal interpretation on the participants views. Given the nature of my philosophical lean towards social constructivism and interaction I felt it would be inappropriate to assume understanding and I consciously sought to develop rapport with the participants by attempting to get them to explore their own meanings and understandings by asking how and why type questions (Williams and Burden 1997:28). Indeed, Winter (cited in Coghlan and Brannick 2010:147) expresses disagreement with giving personal interpretation, stating that 'your presentation should reflect your own process of learning and not be a judgment of others'. He advises against 'making commentaries which place you as the researcher in the superior role of one whose analysis of other people's words shows that you understand what took place while they don't' (ibid). The data used an inductive coding method (Altrichter et al's 1993:124) and the process of exploration used in the interviews supported the self-reflection through 'reflective conversation' that I engaged in as I went about the coding process (ibid).

Results

All four of the participants answered the survey and expressed clear and unambiguous views on the statements. It is important to note that although a detailed quantitative analysis was not undertaken, the overall results were mainly positive and are displayed in table 1 below:

Table 1. Five Disciplines survey results.

Views on	Findings	Rating average
Systems thinking	Overall positive	1.0–1.50
Mental models	Overall positive	1.0–1.75
Personal mastery	Overall positive (exception item 5)	1.25–2.25
Shared vision	Overall positive	1.50–1.75
Team learning	Overall positive	1.0–1.75

Systems Thinking: De Geus (2012:83) emphasizes that 'Rambo style management' is suitable for certain types of decision making but in other cases it may be extremely devastating from a financial and human perspective. Similarly, the associates' opinions elicited views on the importance of considering the consequences of our actions with one associate stating '*very often these companies are making the decision only based on the quarterly reports and so the general feeling there is that people can't see far enough in the future to feel kind of confident'*. These consequences take time to appear and Senge (2006:79) reminds us to be aware of these 'delays'. Viewing events in isolation and the detrimental effects it has on an organisation was also emphasized. They also raised points on the nature of the problem, stating that certain problems may lend themselves to short- term views. However, organisations must be aware of the consequences quick fixes as all too often it results in short-term benefits, limiting one's ability to find the root cause (Senge 2006:103). Nevertheless, Argyris (1999:127) believes that too often we define problem solving through a too narrower lens and being aware of our chosen approach is therefore essential.

Mental Models: Senge (2006:163) suggests that knowing how to access our mental models can contribute to an organisation's creativity and implementation of new ideas. Similarly, the associates expressed support for a company culture where opportunities for creativity and entrepreneurship were nurtured through exploration of these models. Although research regarding distributed leadership is still in its infancy, recognizing its contribution to an organisation's growth and success should not be dismissed lightly and can be encouraged through this approach (Bush et al 2010:57). Harris (2008:176) concurs, highlighting distributed leadership's positive impact on change and organizational development. Furthermore, matching our actions and words emerged as a strong theme with respondents citing the importance of this in building trust and as one associate stated *'It's about being* *authentic'.* Argyris (1999:232) warns that our theories in use are the default position in times of stress and is 'a recipe for ineffective learning', strengthening organizational defensive routines, resulting in 'consistent inconsistency' (ibid).

Personal Mastery: Here the associates' opinions differed concerning the pursuit of meditation, reflection and prayer. Senge (2006:135) explores the challenges of this discipline stating that 'it is difficult even to discuss some of the premises of personal mastery'. He sternly reminds us to allow people to make their own choices (Senge 2006:161) and practising what one preaches is an important strategy for leaders embrace to help others develop this discipline (Senge 2006:162). The associates also made reference to the importance of looking at the bigger picture from the perspective of sustainability with comments such as '*It's not to be used in isolation with your professional work or with the environment - it's everything'.* Pedlar et al (1997:4) concurs, advancing that many companies and the employees stop at stage two of adapting, never fully experiencing the satisfaction that comes from contributing to their work and the greater good of the environment. Senge et al (2010:102) agree, arguing that in order for companies to embrace sustainability, they must start seeing the environment as the centre of the universe as opposed to the economy.

Shared Vision: The interviews elicited opinions on the importance of knowing the company vision; indeed, not just knowing it, but who is actually behind it. Senge (2006:200) has an important message for leaders who are in charge of the vision; namely, if we want to build then we have to share. Promoting organisational belonging was also important to the participants. Senge believes one way to achieve this is through building shared meaning and seeking to develop a collective sense of what is important (Senge 1994:299). For Swieringa and Wierdsma (1992:35) this collective process is a basic component of organizational learning and they state that 'it is a matter of people cooperating; thinking things out together, taking decisions and carrying out activities'. Indeed, this was the starting point of this study and as Williams and Burden (1997:28) conclude 'the human enterprise depends on a shared reality'.

Team Learning: Although conflict may be viewed as having mainly negative connotations it is necessary in keeping the learning process alive (Swieringa and Wierdsma 1992:77; Senge 2006:232). The associates believed that dealing proactively with conflict was important and Wals and Schwarzin (2012:19) agree, listing conflict as a 'sustainability competence', one of several competencies support an organisation's move towards sustainability. However, an important reminder with regards to defensive behavioural patterns is to know your own first as failure to do so may risk the development of learning organisation capabilities (Swieringa and Wierdsma, 1992:78). Argyris and Schön (1996:103) maintain that this self knowledge is a crucial factor in breaking the defensive cycle and resulting conflict, stating that 'For double loop learning to occur and to persist at any level in the organization, the self-fueling processes must be interrupted. In order to interrupt these processes, individual theories-in-use must be altered'

Discussion and conclusions

This action research study shows several key findings; first that involving key stakeholders is advantageous. Clark (2010:413) identifies several reasons for participant commitment, amongst them that 'there is a perception that they are contributing to a research project that offers an avenue for change in their immediate environment'. Developing learning organisation capabilities is not an individual pursuit; in fact, Senge et al (1994:299) hold that inclusion of the organisation's personnel is a crucial factor in developing an organisation's vision as 'to be genuinely shared, such visions must emerge from many people reflecting on the organisations purpose'. Secondly, all four associates placed high importance on the statements, putting us in a strong position to develop an effective learning culture by showing what Bush et al (2010:186) refer to as 'shared agreement'. For Williams and Burden (1997:96) this would suggest that we have the basis for building on their 'construction of knowledge' through the process of social interaction; a critical element for meaningful learning and learning how to learn together (Bush et al 2010:181) and what Watkins and Golembiewski (1995:89) would refer to as 'learning through co-creation'. Moreover, central to the development of learning organisation capabilities is placing the right leaders at the helm. In fact, Swieringa and Wierdsma (1992:83) would argue that it is leadership, as opposed to management, that is necessary to successfully navigate transition periods. However, as one participant stated, good management is vital and this view is supported by Bush et al (2010:5) who state that 'in practice schools and colleges require both visionary leadership, to the extent that it is possible with a centralised curriculum, and [sic] effective management'. In addition, deeper exploration of the Systems archetypes *shifting the burden* showed how by applying a fundamental response can have a more sustainable outcome. Senge (2006:103) suggests that applying a symptomatic solution may temporarily eliminate the problem, only for it to return again at a later date with potential negative side effects. He also warns that constant use of hasty solutions may increase the potential of 'atrophy' in applying fundamental solutions (ibid). Rather, he encourages us to view the optimal choice as the fundamental solution and although there may be delays in outcomes, until one can deal credibly with these issues, the problem is bound to return. Moreover, with regard to reflexivity and reflection a number of benefits were identified. However, as Schön noted, it is not always viewed as credible or perhaps even worthy of an employee's time. As Senge et al (1994:60) point out 'many organizational cultures influence people to skip this stage, partly because of assumption about the way people spend their time. If someone is reflecting, it's considered perfectly acceptable to interrupt them, because "they're not doing anything'. Indeed, the associate's opinions were varied enough as to warrant an extensive in-depth look at how a more positive view of reflection may be conceptualized and applied in daily life. We should accordingly seek to create opportunities for ongoing dialogue between the associates - thereby developing its acceptance and importance for professional and personal growth.

Swieringa and Wierdsma (1992:6) suggest that 'at the basis of every business is the founder' and 'in the early stages of a business, the founder exercises a dominant, cohesive influence in the organization, giving it direction and reducing uncertainty'. If so, then commitment to continually sharing the vision is vital in order to avoid settling for compliance and gaining commitment from employees (Senge 2006:203). Continuing the inquiry process at a first person researcher level is also crucial in order to support the learning process as well as maintaining an ongoing practice of inquiry which pays explicit attention to ways of developing both personal and professional actions. By monitoring behaviour through ongoing reflection in and on action and what Senge et al (2010:50) refers to as problem solving by creating, organisations can challenge the mental models which underpin their behaviour. By proactively seeking to explore theories in use versus espoused theories, congruence in behavior can be achieved by displaying what Reason & Bradbury (2013:499) believe is the 'action' is action research. As a result, this may avoid suffering from what Argyris (1999:5) refers to as a dysfunctional culture syndrome and also supports development of learning leaders. Swieringa and Wierdsma (1992:74) concede that although learning can take place at an individual level, the hallmark of a learning organization is one that engages in collective learning. Argyris and Schön (1996:11) suggest that 'when individuals and organizational inquiry do intersect, individual inquiry feeds into and helps to shape organizational inquiry which then feeds back to shape the further inquiry carried out by the individuals'. By acting as role models and sharing experiences, leaders may encourage similar inquiry in others and as a result, collective learning may spring into action, strengthening collegial relationships through dialogue; an essential ingredient of a successful team. Finally, by working to develop the principles suggested above, the benefits may then be passed on to the wider community through development programs based on experiences and knowledge, However, Reason and Bradbury (2013:6) warn 'attempts at third person research which are not based in rigorous first-person inquiry into ones purposes and practices is open to distortion through unregulated bias'. It is for this reason that knowing how to delve deeper into our own and others motivations and mental models is important, as embarking on broader scale research may be unwise and perhaps even reckless. If, as Coghlan and Brannick (2010:7) claim, 'action research builds on the past and takes place in the present with a view to shaping the future' then we have a strong starting point for refining and developing a sustainable future. As Senge (cited in Scharmer 2009:xviii) concludes 'it is only through this listening that we will unlock our collective capacity to create the world anew'.

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Higher Education Institution Role Integrating Automation-Engineering Students into Factories Sustainable Based on Primary Renewable Sources for Communitarian Sustainable Development Strengthening

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University framework permits human resources availability with engineering students coming from different town. University placement is benefited with itself human resources location and also with the feasibility in the correspondent location of natural renewable sources. These facts are integrated by their authors permitting a link between the theorist and practical knowledge. As example is shown on application to co-generation by sugar cane bagasse in sugar cane factories, etc.

Introduction and Background

The irrational use of resources of chemicals substances in agriculture and industry and pollution, among other factors, destroy in minutes what nature built in thousands of years. As a result of ecological imbalance, the study of the environment has been occupying an important and necessary place in the international arena where they are analyzed and pose political, economic and commercial guidelines to achieve sustainable development, which makes it possible an economic growth without endanger the natural resources that have been inherited from our ancestors and preserve them for future generations. In this context, cleaner production is of great importance because it is necessary to prevent current trends threatening extinction to invaluable resources they have inherited from our ancestors and preserve them for future generations. For the Cuban nation, the sugar cane is an integral part of its history, culture and tradition. The database provided by FAO shows how sugar cane was the main product in the Cuban economy for years. Sugarcane has been planted, historically, with the basic purpose of producing and marketing sugar. Also factories producing sugar cane, besides being the most productive tradition since the time of colonization by Spain several centuries earlier, are a type of industry necessary for the production of human and animal food, and for cogeneration of electricity from bagasse. In the sugar mills energetic generation system is known as cogeneration that is nothing but the process by which electricity and useful thermal energy (steam) is simultaneously obtained. Its advantage is its greater energy efficiency since both heat and mechanical or electrical energy of a single process, instead of using a conventional power plant for energy needs and for heat needs a conventional boiler. The goal of cogenaration is not to lose this large amount of energy. While large thermal power companies seek only power generation and dissipate heat generated to the environment, cogeneration plants, taking advantage of this heat, they get a much higher overall efficiency. Precisely, this primary source of fuel (bagasse) ranks as the plant operating with renewable green source. However, proper automation of steam generation in the boiler is needed to reduce the bad composition with the air polluting gases are expelled and to ensure the proper treatment of waste that currently discharges to rivers and streams nearby .

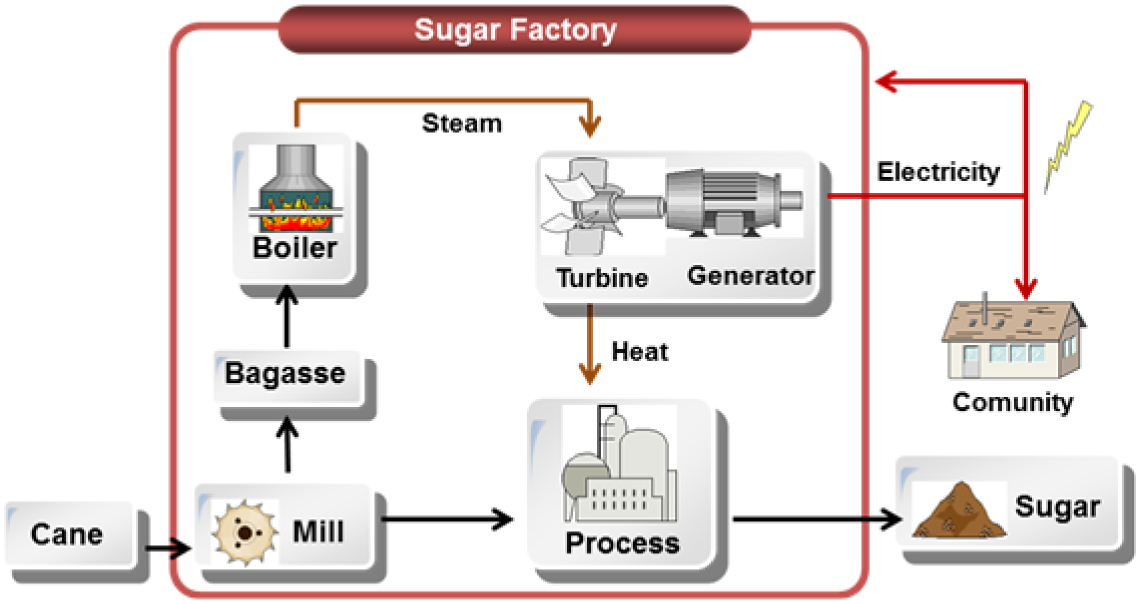

Figure 1: Simplified sugar cane production cycle in Cuban factories: industrial structure benefiting energy co-generation and sugar as food production.

Material and Methods

The Department of Automatic Engineering, University of Oriente is responsible for the training of Automatic engineers in 5 provinces in eastern Cuba. The annual average is 60 students input. In the third and fourth year of the course students should do their studies in a period known as labor practices which are inserted into different business entities related to their specialty. During this period, students are gaining practical experiences that enrich their knowledge and skills for your future career. Each academic year has a number of no less than 15 young people from municipalities in each of the provinces in which the socio-economic activity takes place around a sugar factory and these are chosen for their period of practice labor. During its course, the students manage to create strong links with workers forming good teams in which each learns, exchange knowledge, etc.

In recent times, sugar factories have invested introducing a supervisory computer that stores large volumes of industrial measurements throughout the period of the harvest. It is known that within historical records obtained from instrumental measurements there is potential information to find the factors affecting the operation of the plant by identifying those variables that are influencing the efficiency and performance of the same, however, these mines are being undervalued and data are not used for a deep causal diagnosis. At the same time there is a need for training of technical, youth dedicated to the evaluation of the chemical processes, and instrumentation and control systems have been introduced.

Taking this into account, besides the knowledge of the process operation, instrumentation and automatic plant, in the last years has been created a multidisciplinary team of professors and students at the university dedicated to application of processing techniques of times series corresponding to dozens of measured variables as daily practice and to create data mining to extract useful information of how the operation of this thread goes. This group has been given the task of linking Eastern University with the sugar industry through students who come from their villages in order to strengthen the assimilation of new computing technologies in the production of energy and food and create simultaneously an environment conducive to motivating youth activity in this rural environment.

Figure 2: Current location of sugar cane factories in the eastern part of Cuba which automation engineering students coming from to our University of Oriente in Santiago of Cuba.

As part of the work to be done, it must first take inventory of problems that exist during operation of steam generation, evaluate the availability of monitored variables in contrast to the information required for diagnosis of the operation in harvest's time and development of software applications to extract useful information aimed at increasing energy efficiency and prolong the useful life of the investment and to diagnose automated problems inventoried for detecting short and long-term operational problems, deterioration of components, etc.

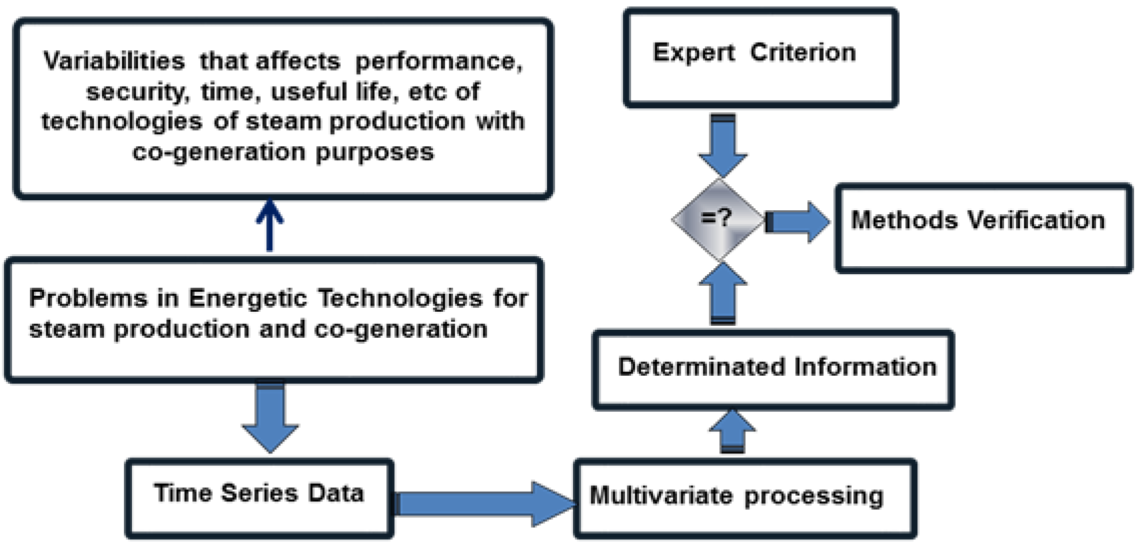

Figure 3: Process monitoring and diagnosis in sugar mills.

Variable selection is made on the basis of a criterion to evaluate the effects of degrading actions. Typical variables are monitored:

- Vapor pressure in the load
- Steam temperature in the load

- Weed water Pressure
- Feed water Temperature
- Fan speed
- Pressure in the furnace
- Air temperature.

In a sugar mill steam demand exhibits a significantly variable pattern denoting the presence of a dynamic operation and cause fluctuations in vapor pressure. The fuel characteristics are also very fluctuating because the calorific value and their physico-chemical properties are greatly affected by the type of cane, moisture and dirt.

Monitoring of deviations is the way to observe the effects of degradation of equipment and heat exchangers as these are a reflection of the capacity reduction in equipment performance that has occurred over time. Of degradation of equipment and processes, fouling exchange surfaces is the most impact on the efficiency factors and plant availability. Exchangers degradation by fouling is reflected in power loss and hence must be increased fuel consumption and leads to performance degradation. Rising dirty air heaters reduces heat transfer to the air temperature affect on reaching the furnace for combustion. The not transferred energy from the gas is lost at high gas temperatures at the outlet of the chimney and affects the environment.

The goal of diagnosis is to detect deviations from the correct operating conditions and after the occurrence of any anomalies. Any deviation occurs between variables or their parametric characteristics in two conditions of operation may be attributed to the presence of anomalies. Once the inventory of possible anomalies defined, then, the scientific approach is given by the solution of the inverse problem, from the identification of the effects, determine or infer their causes. This way we can determine the factors that are negatively affecting the proper operation and efficiency of the plant and especially those affecting the quality of combustion with consequent increase in polluting gas emissions to alert operators so that it can be corrected this situation in the shortest possible time.

Results

The advantages of this link between the University and the sugar industry are many:

- Is the training of human resources exploiting bagasse boilers and engineering students in auto factories in sugar production of the 5 municipalities of eastern provinces.
- Improvements in documentation of the cogeneration process resulting from an accurate survey and renewing the inventory of existing technological solution particularly for each sugar factory.
- Increase in economic benefits to achieve greater operational efficiency and extend the useful life of the facility giving use to mine data from historical records in order to promote operational diagnosis of this extracting useful information.
- Decrease in scheduled maintenance costs per year and the decline in unscheduled repairs during the production stage which leads to increased productivity both sugar and molasses waste used for animal consumption in livestock farms and plus the amount of electrical energy that is supplied to the electro-domestic power system increases.

- Reduced emissions of polluting gases into the environment to increase the quality of combustion.
- Improves quality of life disposed near a solid residue product (small pieces of burned bagasse) is generated poor combustion and falling on their homes and clothes settlers.

Discussion and Conclusions

As a result of this collaboration each year more and more students are interested in doing their jobs in this area and achieve environmental awareness of the importance of this work to achieve the reduction of emissions of polluting gases into the atmosphere, now totaling more than 15 bachelor works that have been made based on this type of research successfully in over 9 sugar factories all Eastern provinces. Is intended this collaboration with colleagues from the other regions to also be able to take these results at national level.

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Visions for the Mining Industry in the Future Low-Carbon Society in Finland

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Finland has undergone a marked growth in mining activity in recent years, driven by a persisting demand of metals in international markets. At the same time, the pressures towards lowering the carbon intensity of societies are increasing and encourage seeking breakthroughs in energy technology development. Greater investments to a low carbon society can lead to an increasing need for high-tech metals and decreasing demand for base metals, which dominate the present metallic mining production in Finland. Opposite development could be triggered by unstable political or economic conditions or in case of implementing business-as-usual policies with limited interest in GHG mitigation. The focus of this study was to model the development of the Finnish metal mining industry in context of reaching the 80% GHG emission reduction target. Our assessment has special emphasis on increasing demand for high-tech resources, which are closely associated with the key energy technologies of the future. Four modelled development scenarios show variations in the intensity of mining and related GHG emissions. Based on our results the key aspect of the mining industry in reaching the GHG emission reduction target is to invest in energy efficiency and electrification in processing technologies and use of biofuels. In addition, investments in clean-tech mining machinery and low-carbon process optimisation could support mitigating negative climatic and environmental effects of mining in the operating and future mines.

Introduction and Background

Finland has proved to be one of the most interesting countries for mineral exploration during last couple of years (Wilson et al. 2013), and also the actual mining activities have increased markedly since 2007 (PwC 2012; Tuusjärvi et al. 2014). This is driven by persisting demand for metallic mineral raw materials for both sustaining the materialistic well-being of developed countries and for building the well-being in developing countries, most notably in China. At the same time, there is an urgent need for dematerializing and decarbonising the societies to sustain common human well-being for long-time perspectives at our planet. On 8 March 2011 European Commission launched A Roadmap for moving to a competitive low carbon economy in 2050 (EC 2011a) and on 15 December 2011, it adopted the Communication "Energy Roadmap 2050" (EC 2011b). Based on these roadmaps the European Union (EU) has set a long term target to reduce its greenhouse gas (GHG) emissions by 2050 by at least 80% compared to the 1990 level. Each Member State should identify their own sustainable pathways to reach the target, which would take into account national circumstances, like natural resources, industrial structures, public acceptance, and other societal dimensions. Finland has set up a parliamentary energy and climate committee to formulate low carbon roadmap for Finland.

The Finnish mining industry has a long history in Finland and until mid 1990´s mining operations and exploration activities were done only by state owned companies in addition to exploration work carried by governmental institution (Puustinen 2003; Tuusjärvi 2013). Opening of opportunities for foreign companies in mid 1990´s changed the situation fundamentally, and after the increase in metal prices in the early 2000´s the exploration in the country was notably intensified. There was also several mine development projects which led to an opening of new gold and base metal mines. During the 2012 and 2013 the metal prices have fallen again which has led to the withering of most of the exploration and new development activities in the country. Currently there are 8 operating metal mines and four metal mines with suspended status in the country. In addition, several new projects are in the pipe-line although the development plans have been commonly postponed due the challenging economic situation. In addition to metal mining, Finland also has several industrial mineral mines utilizing, for example, carbonates, talc and phosphorus, but those are not considered in this study.

At present, the mining industry has a relatively small contribution to the total GHG emissions in most countries, including Finland. According to IEA (2012b) the mining industry accounted globally for about 3% of the total industrial final energy use in 2010, and about 2% of the direct energy-related industrial CO_2-eq emissions. Almost 40% of the final energy consumption consists of electricity. In Finland, the metallic mining industry accounted for less than 1% of the total final energy use in industry in 2010, and over 40% of the final energy use was electricity (Statistics Finland 2013).

The CO_2-eq emissions on mining are mostly related to energy use, but also on some chemical reactions on mineral processing. Energy use is correlated with the amount of processed ore and its qualities, especially on hardness. Increased energy use is usually related to increased grinding (Norgate and Jahanshahi 2006) and the mining of low-grade ores usually requires more energy than mining of high-grade ores due to the increase in the amount of ore to be processed (Norgate and Jahanshahi 2010; Mudd 2007, 2010a,b; Glaister and Mudd 2010). There are also differences in the energy use in open pit and underground mining (Natural Resources Canada 2005a, b). In addition to energy use, used processing method might be CO_2-intensive. Examples include liberating carbon dioxide (CO_2) in neutralization process of sulphuric acid with limestone and hydrogen manufacturing from liquefied petroleum gas.

In this paper, we describe how the metal mining industry would possibly react to different development paths towards the low carbon society in Finland by 2050, what kind of role this industrial branch has in decarbonisation of Finland, and which factors seem to be the most influential in decarbonising this industrial branch in particular. In addition, our interest was to study how the increasing global demand for high-tech metals needed for innovative energy technologies would affect the mining industry in Finland.

The formulation of the mining scenarios was based on heuristic analysis on how the metal mining in Finland could be affected by the societal changes expected in four societal scenarios defined in Low Carbon Finland 2050 -platform (LCFinPlat) project. The societal scenarios 1) *continued growth*, 2) *transformation society*, 3) *save* and 4) *stagnation* are based on narrative storylines and systematic modelling.

This paper is structures as follows: 1) Materials and Methods, 2) Results and Discussion and 3) Conclusions.

Material and Methods

Setting up the scenarios for the low carbon future in Finland (Societal scenarios)

The societal scenarios were formulated with different visions on how the material and energy efficiency of the Finnish society would change, how soon new, clean energy technologies would emerge, and what might be the overall economic structure and economic growth when aspiring towards the -80% reductions in national carbon emissions in Finland. These results of these scenarios are reported by Koljonen et al. (2014) but are also shortly described below.

Due to the practical impossibility of making predictions of the future up to 2050, the analysis of transition to low-carbon society was carried out by exploring alternative scenarios. The elementary approach in the creation of scenarios required them to be sufficiently different in order to make a broad-based assessment of the future from different viewpoints. The process of creating the scenarios in the projects includes 1)"Low-carbon storylines" describing the operational environment and background logics, and 2) computational analysis. Important part of the project was a creation of interactive platform, which was implemented by a series of seminars, workshops, consultations between different interest groups and between experts, as well as a broad questionnaire targeted at private consumers, contributing as a whole to the target of interactivity (Figure 1). The creation and analysis of low carbon scenarios for Finland aimed at broad-based utilisation of viewpoints of different interest groups and consumers, and, on the other hand, utilising the assessments of sustainable use of natural resources, like mineral resources as presented in this paper. During the project three larger workshops were arranged, where experts, NGOs, policy makers, industrial actors, and researchers were participated to formulate the scenarios and to give feedback in the 2nd and 3rd workshops. In between the workshops, computational analysis with VTT-TIMES model (Loulou 2008; Loulou & Labriet 2008) was carried out to better assess the challenges and opportunities in transforming Finland to a low carbon society. The platform also included a consultation of the above mentioned energy and climate committee to formulate Finland's low carbon roadmap.

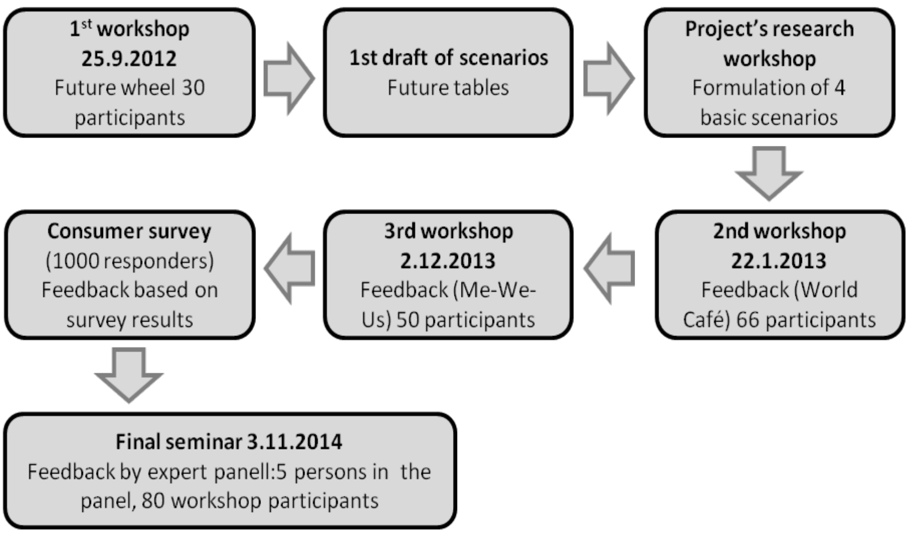

Figure 1. Formulation of the societal scenarios in the Low Carbon Finland Platform 2050 -project.

The scenario matrix was finally formulated according to Dator (1981), who has compressed the range of futures into four archetypes – *continued growth, collapse/decline, conserver/disciplined society,* and *high tech transformation.* Accordingly, the societal scenarios were named as *continued growth, stagnation, save, and transformation society.* In all the scenarios the expectation is that both Finland and the EU will achieve the 80% GHG emission reduction target by 2050 compared to the 1990 GHG emission level. However, the global climate policy is expected to be different: in *continued growth* and *transformation society* scenarios the global GHG emission path follows the 2 °C mitigation while in the *stagnation* scenario the global average temperature rises up to 4 °C during this century. In the *save* scenario, the EU decides to take a global lead in climate change mitigation and reaches the 80% GHG reduction target already in 2040. In the *continued growth* and *transformation* scenarios free global trade and implementation of clean technologies are expected to ensure growth of the global economy. In the *stagnation* and *save* scenarios regional policies leading to more conservative technology mix as well as slowing down of economic growth are expected to exist in Finland and EU. In the *stagnation* scenario, global climate change is expected to cause considerable risks and damages to a global welfare.

Setting up scenarios for the metal mining industry (reflections to the societal scenarios)

The scenarios for the metal mining industry were based on heuristic analysis on how this industrial sector would be affected by the societal changes expected in the societal scenarios (called here *reflection scenarios*). The scenario formulation was based on two project-internal researcher workshops that included experts from GTK and VTT (in total eight researchers were included in the workshops). In addition, the scenarios were further adapted to the changes in the societal scenarios with email based heuristic information sharing between the members of this researcher group. In addition, comments for the mining industry scenarios were also gathered in the societal scenario workshops and by the internet based open questionnaire (December 2013) presented in Figure 1.

The aim of the heuristic analysis was to create reflective scenarios to answer on *how the industry is expected to react to the changes in national economy, policy and in the demand of metal resources* estimated at the societal scenarios. This was slipped on to four questions:

1. Is there a free, international trade of minerals and is the availability of minerals from these markets secured for Europe?
2. How efficient are recycling and replacing activities, and how efficient societies are in terms of materials use?
3. How intensive is the demand for base metals and critical metals?
4. Will an environmentalism increase and what is the general attitude towards nuclear power and uranium mining?

Current situation at the Finnish mining industry formulated the starting point for the reflection scenarios. In addition, the global trade on minerals was expected to continue ensuring the availability of metal raw materials from global markets. An exception was made on *stagnation scenario* where we expected the international markets to wither and that most of the demand for metallic raw materials would arise from national and European market.

To model the expected changes in the metal mining sector, the mining model developed earlier in a project "Sustainable Use of Natural Resources and the Finnish Economy" and described by Tuusjärvi et al. (2014) was used with updates to 2050. This is a supply based model, using mine-by-mine or deposit-by-deposit data as primary data, with narrative scenario descriptions. The database is based on public data sources, for example annual reports and other company reporting, public authority reports and environmental impact assessment reports. The expected amount of ore mining at each mine site in the studied years serves as the variable factor in the model, and the industry-wide results at the end-years are derived by aggregating the mine-specific results. In addition, expected change in the energy efficiency was modelled using the VTT Nordic-TIMES model (Loulou 2008; Loulou and Labriet 2008). The modelling takes into account expected changes in energy efficiency and decarbonisation of the electricity system, but excludes the use of CCS-technologies and biofuels at the mine sites.

The fuel consumption in the Finnish mining industry consist primarily of oil products used for trucks and trains and other are work machines, as well as on-site electricity generation, heating of the surface buildings and process steam generation. Liquefied petroleum gas (LPG) is also being used for producing hydrogen for the metal recovery process. According to Statistics Finland (2013), the use of solid fuels is negligible in the Finnish mining industry.

Results and discussion

Scenarios for the metal mining industry in a low carbon Finland

Four different reflection scenarios were formulated for the development of metal mining industry within the societal scenarios. The main societal changes expected to have effect on the metal mining industry are illustrated in Figure 2. The connective factor in *transformation* and *save* scenarios is the expected decreased demand of base metals due to increased recycling, substitution and/or materials efficiency. In the contrary, demand for base metals was expected to increase in *continued growth* and *stagnation* scenarios. In addition, the connective factors for transformation society and continued growth are moderate economic growth and new energy technologies. For *save* and *stagnation* scenarios the connective factors are low economic growth and traditional technologies.

All of the reflection scenarios expect that there will be new mines in Finland although the mining projects expected to develop into mines vary according to the pre-conditions presented in Figure 2. In addition to this we modelled a scenario (called here a minimum scenario) that reflects a situation where no new mines are opened nor new mineable reserves identified in currently operating mines (potentially increasing the life-span of the mines).

The reflection scenarios presented in this paper are not exact projections of the future but present possible paths on how the mining industry could possibly develop in different societal settings.

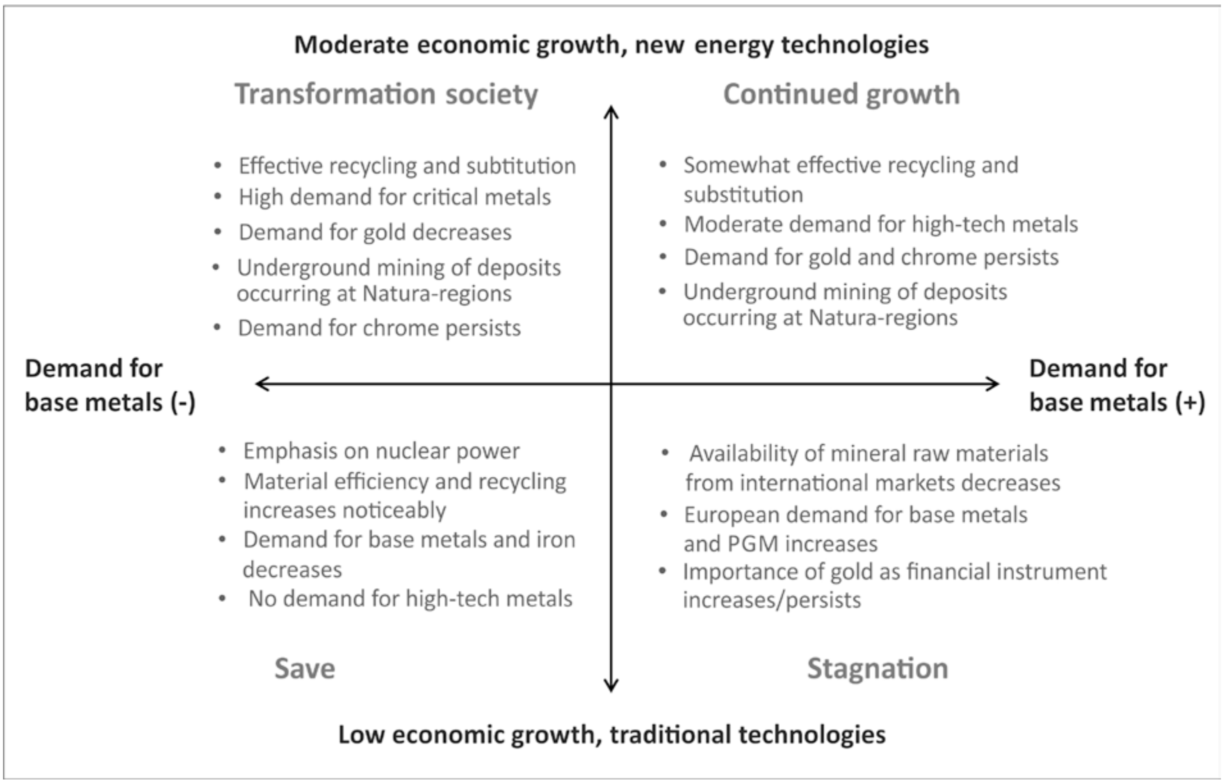

Figure 2. Changes in the society which are expected to have effect on the metal mining industry in different scenarios.

Possible low-carbon development paths of the mining industry in Finland

After formulation of the reflection scenarios, their possible effect to the development of the metals mining industry in Finland was modelled using five indicators: 1) amount of ore mined, 2) fuels used, 3) electricity used, 4) amount of direct GHG emissions from fuel use and process, and 5) amount of indirect emissions. Changes in these indicators were modelled for all formulated reflection scenarios and presented in Figures 3 and 4. In addition, for the amount of ore mining the minimum scenario was modelled, reflecting the situation where no new metal mines are opened and no additional mineable reserves are found in currently operating mines.

The amount of mined ore (Figure 3)

The main differences between the reflection scenarios seem to be bound to the amount of mining from base-metal mines and not so much to the critical metals. For example, the general assumption made in *transformation society* and *save* -scenarios was the down turn of the base metals industry, when in the *stagnation* -scenario the base metals industry was expected to continue strong. The known deposits for critical metals in Finland are relative small so they don´t currently have a capacity to have a reasonable effect on the metal mining industry in the country. An exception is made by the platinum group metals (PGM) which occur together with base metals in relatively large ore deposits on the Northern Finland. *Transformation society* and *continued growth* scenarios show a peak in the amount of ore mining in 2040 based on the expected utilization of these PGM deposits (*continued growth*: in addition to the expected reopening of Talvivaara in 2040).

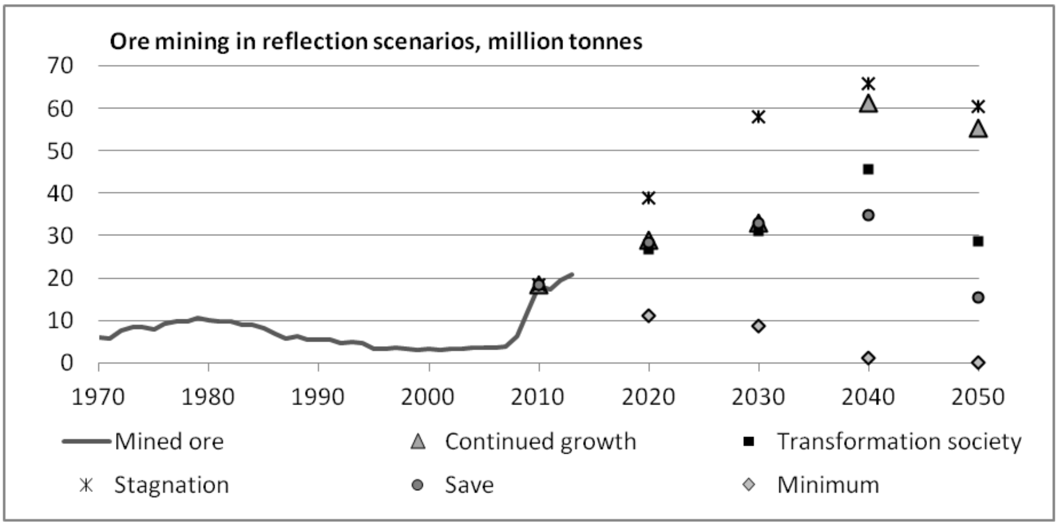

Figure 3. Change in an amount of mined ore in the reflection scenarios. The minimum scenario represents the situation where no new metal ore mines are opened and no new mineable reserves are found to exist in already operating mines.

All reflection scenarios (expect the minimum scenario) show an increasing trend in the mining activity until 2040. After this there is a declining trend which is based on the depletion of the known resources on currently active mines, and in the currently known deposits which may proceed to mines in the future. New findings and/or increasing metal prices could, however, prolong the operational age of the currently operating and upcoming mines.

An underlying uncertainty in the ore mining projections is the uncertainty related to the opening of new mines. There are currently several projects in pipe-line at different development levels (from advanced exploration targets to mine projects waiting for the opening decision). The development of these projects is bound to the economic situation of the companies (is it feasibility enough to make a decision to open a mine) and permitting of the projects (e.g., environmental permits). These are affected, for example, by the quality of the mineral deposit, general economic situation and permitting procedures.

Fuel and electricity use (Figure 4)

Modelled increase in the fuel use in reflection scenarios is almost proportional to the increase in the amount of ore mining. This is reasonable as most of the fuel is used on the mine sites for transportation of the ore. Also the electricity use reflects the amount of mined ore in reflection scenarios, but has a more intensive increase in the beginning of the dissected time period. This is due to the expected reaching of the full operational level in new mines opened after 2010 such as Kevitsa and Suurikuusikko, and expected starting of mining operations at Hannukainen and Mustavaara. As these mines are using more electricity than fuels per mined tonne of ore, their aggregated effect on the electricity use is greater than to the fuel use.

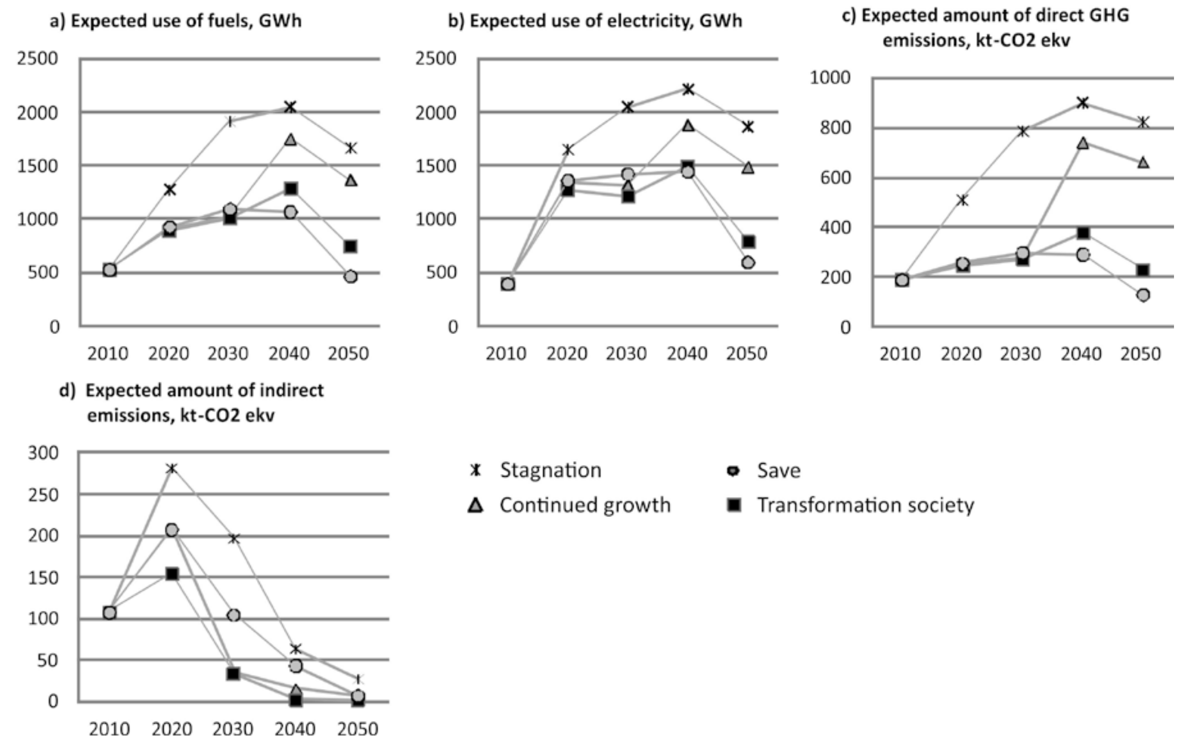

Figure 4. Expected change in different low-carbon scenarios in a) expected fuel use, b) expected electricity use, c) direct, on-site GHG emissions based on fuels and process emissions, and d) indirect off-site emissions based on electricity use at metal mines in Finland.

GHG emissions (Figure 4)

The modelling indicates that the energy use at the mine sites will be affected by the general increases in the energy efficiency in the expected low carbon Finland. This will have effect also on the energy related CO_2-eq emissions: direct on-site emissions related to fuel use and process based emissions, and in-direct off-site emissions related to electricity use. However, the trajectories of the direct emissions between 2010 and 2050 vary significantly, from –90% to +210%, including both fuel and process emissions. The highest reductions are expected to be achieved in the save and change scenarios, while the stagnation scenario shows the highest increase in emissions. The continued growth scenario shows a moderate increase.

Due to decarbonisation of the electricity system in the societal scenarios based on the increased use of CO_2-eq neutral sources in electricity production, the additional growth in electricity consumption at mine sites does not, by itself, pose an obstacle for reaching the carbon reduction targets. According to the results the indirect CO_2-eq emissions related to electricity use at metal mines will eventually approach zero in all scenarios except stagnation. The stagnation scenario falls short of accomplishing the low carbon targets also in the societal scenarios, which can in part be attributed to the mining industry.

The results suggest that the role of non-fuel on-site emissions based on the mineral processing technologies will potentially increase in the future (Table 1). These emissions are most often related to chemical reactions between lime and acid and are used mostly for neutralizing and water purification purposes. According to this, the CO_2-eq reduction purposes could also benefit from process design focusing on reducing the use of acids and/or other chemicals related to CO_2-eq emissions at mineral processing.

In addition to the increased energy efficiency and decarbonisation of the electricity system modelled in this study, the important options for cutting the direct emissions at mine sites could be to be substitution of diesel and heavy fuel oil with bio-oils, electrification, CCS-technologies, efficiency improvements and process optimisation.

Table 6. Expected share of process based CO_2-eq emissions of the total on-site GHG emissions in modelled scenarios

	2010	2020	2030	2040	2050
Continued growth	30 %	0 %	0 %	39 %	47 %
Transformation society	30 %	0 %	0 %	9 %	15 %
Stagnation	30 %	33 %	36 %	41 %	48 %
Save	30 %	0 %	0 %	0 %	0 %

Conclusions

In this study we formulated and modelled four different scenarios for metal mining reflecting the societal scenarios formulated in the Low Carbon Finland 2050 -platform. In addition, a minimum scenario was modelled to reflect the situation where no new mines are opened and no additional reserves are indicated in the operating mines. The modelled indicators include: 1) amount of ore mined, 2) fuels used, 3) electricity used, 4) amount of direct GHG emissions from fuel use and process, and 5) amount of indirect emissions.

All the reflection scenarios (expect the minimum scenario) show an increasing trend with differing intensity in the mining activity until 2040. Towards 2050 there is a declining trend based on the depletion of the known resources on currently active mines, and in the currently known deposits which may proceed to mines in the future. The mines utilizing base-metals and iron have greater effect to results than demand for high-tech metals, for which the known deposits in Finland are small.

Also the fuel and electricity use is expected to increase at the mine sites due to the modelled opening of the new mines. In addition, the expected reach to the full scale production at several mine sites (opened just before or after 2010) have an effect to the results. Energy use at the mine sites will be affected by the expected increases in the energy efficiency. This will have an effect also on the energy related CO_2-eq emissions (direct and indirect) at the mine sites. In addition, the expected decarbonisation of the electricity system will reduce the indirect GHG emissions related to the electricity use at the sites.

In addition to the increased energy efficiency and decarbonisation of the electricity system modelled in this study, the important options for cutting the direct emissions at mine sites could be substitution of diesel and heavy fuel oil with bio-oils, electrification, CCS-technologies, efficiency improvements and process optimisation.

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The Business Case for Environmental Sustainability: Embedding Long-Term Strategies that Enhance Environmental and Economic Performance

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Current environmental demands, such as the need to meet governmental climate change adaptation targets or to avoid future resource scarcities have created a business opportunity for firms that eschew business as usual and adopt ambitious environmentally focused systemic innovations. This article aims to present a clear business case for corporate environmental sustainability in order to increase investments in this area. The core focus is on the tangible economic benefits that can be realised through environmental strategies such as risk reduction and efficiency gains. The aim is to show that sustainability can be an opportunity rather than an obligation and that not only can environmental and economic performance be optimised simultaneously but that economic performance can be optimised through environmental strategies. It is expected that this approach shall increase competitive advantage while supporting climate change mitigation. The article also highlights the current drivers that provide motivation for environmental performance improvement such as global trends towards resource efficiency and the exposure to long term environmental risks. Sustainability is a multidimensional subject that involves a diverse range of operational processes and it is argued that a greater portion of sustainability resources should be invested in ambitious environmentally focused systemic innovations. This will enable sustainability to be strategically integrated into the core business practices. Embedded sustainability is the term used to describe a high level of sustainability integration.

Introduction

The current rate of environmental performance improvement is not sufficient to meet governmental climate change adaptation targets or to avoid the potential resource scarcities relating to the growing number of middle class consumers (Peters, 2013; Rogelj, 2013; McKinsey, 2011b). This performance gap has accelerated the need to go beyond the incremental innovation and short-termism of business as usual and transition to strategic, systematic, and integrated strategies that result in innovative long term solutions (Lubin and Esty, 2010). The aim of this article is to demonstrate the business case for ambitious environmentally focused systemic innovations that has been created by the need to support climate change mitigation and to adopt resource efficient strategies. The business benefits that can be harnessed by embracing sustainability have been widely discussed and verified, however, the potential has only been fully explored by a small portion of organisations. In this article we examine the business case for corporate environmental sustainability. The business case is concerned with the arguments and rationales that support investments in environmental impact reduction activities. It aims to show that not only can environmental and economic performance be optimised simultaneously but that economic performance can be optimised by adopting environmental strategies. It is expected to increase competitive advantage while supporting climate change mitigation**.** The concept is reflected in the Schaltegger et al. definition that a business case for sustainability is characterised by creating economic success through (and not just along with) a certain environmental or social activity (Schaltegger et al., 2012). The approach is also in line with the argument made by Lovins and Cohen that lowering resource consumption is the most efficient way to maximise profits (Lovins and Cohen, 2011). In the past, corporate sustainability has been viewed by companies as a cost and an obligation that reduces profits. However, recently companies have begun to see social and environmental responsibility as an opportunity rather than an obligation and companies are now aware that they can simultaneously optimize financial, social, and environmental performance (Ludema et al., 2012). Economic benefit is often the primary motive for investing in environmental strategies, however the inspiration for the new approach typically stems from the ability of environmental viewpoints to challenge the prevailing organisational logic. Thus this approach can be utilised to unlock creative solutions to traditional operational efficiency problems by viewing them from a fresh perspective. The traditional cost-conscious business and management viewpoint will be complemented by an environmental viewpoint and existing and emergent environmental issues will be leveraged to drive competitive advantage. The primary aim of this article is to demonstrate the business case for corporate environmental sustainability for organizations that consume substantial amounts of resources and thus this article is primarily concerned with solutions for large corporations rather than small and medium enterprises (SMEs). Large companies are defined as employing more than 250 employees and SMEs are defined as smaller than this (OECD, 2005). It is argued that the adoption of these solutions could lead to substantial reductions in environmental impact for large corporations while also increasing the demand for sustainable products and services which are supplied by SMEs.

Environmental strategies are concentrated on, as relative to social sustainability, the resulting economic benefits are more tangible and thus a clear and direct business case can be presented. The business case of environmental actions is more direct and tangible as it analyses internal company operations that can be quantified in financial statements. Typically, environmental strategies can be evaluated through return on investment calculations that consider items such as investment cost, savings produced from the investment and the estimated reduction of long term risk. Alternatively the business case of social actions is less direct as it involves intangible business elements such as reputation, employee satisfaction and consumer insight. The benefits of social sustainability are equally relevant however, the economic benefits are less direct. In addition, it is argued that the environmental and economic performance of sustainability activities could be enhanced by streamlining the focus area of sustainability to a manageable number of ambitious environmentally focused systemic innovations. As part of this streamlining process, firms are encouraged to embed environmental sustainability which involves integrating sustainability strategies into core business processes. Previous research has divided business cases into four dimensions which are risk reduction, efficiency gains, social branding and new market creation (Hockerts, 2014). This article will focus on risk reduction and efficiency gains in detail while also briefly discussing new market creation and social branding. In the context of this article, new market creation is not dealt with in detail as it is concerned with eco-niche products and services that only appeal to a minor segment of consumers. Similarly social branding is not focused on as the associated business case is considered overly indirect.

This article's specific contribution is to highlight the business case for implementing ambitious environmentally focused systemic innovations in large organizations that consume substantial amounts of resources. It is argued that economic performance can be optimised through sustainability by (a) focusing on strategies that have a direct business case, (b) rationalising sustainability investments and (c) integrating sustainability into the core of the company's business processes. The literature that is discussed in this article is related to the overlap between business, sustainability and innovation. The aim of the review was to illustrate the need to go beyond business as usual to meet the current environmental demands, to present the current understanding with regard to the business case for sustainability and to promote the concept of embedded sustainability. The remainder of this article has been structured so that the topics are analysed as follows: the drivers of corporate motivation are discussed in the next chapter in order to present the current understanding with regard to the interplay between business and sustainability. Section three discusses the importance of the integration of sustainability with core business practices and section four examines embedded sustainability in detail. The final section provides a discussion, conclusions and suggestions for future research.

The Drivers of Corporate Motivation

A Shift in Environmental Policy

Although substantial progress has been made in the field of corporate sustainability it is argued that the current rate of environmental performance improvement is not sufficient, to meet governmental climate change adaptation targets. The European Commission plans to reduce greenhouse gas emissions by at least 80% by 2050, compared to 1990, with the intention of keeping climate change below 2^{o}C (European Commission, 2011). This target will not be met through the incremental innovation of business as usual. Instead it will require a fundamental shift in operating policy for resource intensive organisations. Peters et al. claim that meeting the European Commission target will require "immediate significant and sustained global mitigation, with a probable reliance on net negative emissions in the longer term" (Peters et al., 2013) and Rogelj et al. argue that this target will not be achieved without imposing global carbon taxation (Rogelj et al., 2013).

Hart and Milstein describe corporate sustainability as being complex and multidimensional (Hart and Milstein, 2003). It is a subject that involves a diverse range of processes from supply chain ethics to waste reduction and this can be problematic when choosing corporate sustainability policies. Often stakeholders require companies to be active in all areas of corporate sustainability and when this is coupled with limited budgets the consequence is often a diluted end result. This exposes the dichotomy of stakeholder expectation and the current level of corporate resources being dedicated to sustainability. A similar observation is made by Stiglbauer et al., who argues that companies frequently adopt a scattergun approach for their social sustainability activities (Stiglbauer and Häußinger, 2013). With this in mind companies are encouraged to maintain the minimum best practice standards with regards to social and environmental sustainability and to invest additional resources beyond best practice in environmental sustainability. Companies can achieve the aforementioned shift in operating policy by substantially increasing investment in environmental solutions. The aim of this ecocentric (Shrivastava, 1995) approach is to rationalise sustainability strategies and to improve the shareholder perception of corporate sustainability by only focusing on strategies that have a strong tangible business case. It is expected that raising the economic credibility of corporate sustainability shall result in increased investment in environmental strategies and shall eventually lead to increased investments in social sustainability in the long term. When a firm experiences success through environmental management initiatives, organisational support tends to amplify and opportunities are explored in other departments such as customer service and marketing (Valentine, 2012).

It is argued above that corporate sustainability in its current form is not a high priority for the companies that are implementing it. Lubin and Esty have stated that corporate sustainability should transition from being an ad hoc and peripheral concept to being integrated into the company's core business processes (Lubin and Esty, 2010). In its current form corporate sustainability is a multidimensional subject that involves the implementation of a high number of minor strategies. The approach outlined in this article argues that increased impact could be achieved by streamlining the focus area to a manageable number of ambitious environmentally focused systemic innovations that would strategically redesign operational processes. It is anticipated that successful implementation of these large scale innovations would result in substantial growth in sustainability activity over time.

In addition to risk reduction and efficiency gains, the business case for environmental sustainability can also be applied to new market creation and social branding. New market creation will be used to describe eco-niche products and services which provide a specialist offering and attract a price premium relative to mainstream products and services. Eco-niche examples include organic foods, natural cleaning products, grid power generated by renewable energy, premium products made from recycled components and low carbon transportation services. The focus of this article will not be on eco-niche products and services as these products only appeal to a minor segment of consumers. Also, innovative product and service offerings that are developed by companies in their attempts to radically improve environmental and economic performance will be considered as a result of risk reduction and efficiency gains and not as an example of new market creation. There are also economic benefits for companies who enhance their brand image by being recognized as company with a low environmental footprint. There have been a number of studies that have shown that consumers will be more loyal to a brand that is actively reducing its environmental impact (European Commission, 2009; Koller et al., 2011). Although, social branding is a key consideration for companies when aiming to improve their environmental performance, the economic benefit that can be derived is intangible and indirect in nature. It is more difficult to quantify the social value of environmental sustainability in economic terms than it is for risk reduction or gains in cost efficiency. For this reason it is not expected to be an important component when developing environmentally focused systemic innovations. It should however, be an important part of stakeholder communication once environmental strategies have been implemented.

The Resurgence of Resource Efficiency

The concept of sustainable consumption and production is currently undergoing a resurgence despite the fact that it dates back to the Rio Earth Summit in 1992, when the summit called for "patterns of consumption and production that reduce environmental stress and will meet the basic needs of humanity" (United Nations, 1992). Similarly the sub-branches of sustainable consumption and production such as industrial ecology, eco-efficiency and cleaner production are all greater than 20 years old however, there has been a recent revival in this area. This revival is the result of a greater awareness of resource efficiency due to the emerging environmental risks associated with climate change and resource scarcity. In 2011 McKinsey warned companies of the future risks to economic success that are posed by the influence of environmental degradation on resource availability, the increased demand on resources caused by an additional 3 billion middle-class consumers that will exist by 2030 and the need to combat climate change. McKinsey also encouraged companies to embrace resource productivity and to prepare for the introduction of a carbon tax and the removal of energy, agriculture, and water subsidies (McKinsey, 2011b). In 2012 KPMG announced their concern that costs due to environmental factors could pose a threat to economic success and claimed that external environmental costs for 11 industry sectors rose by 50% between 2002 and 2010, from €450 billion to €680 billion (KPMG, 2012). The companies most at risk are those that consume substantial amount of resources. This not only includes the primary sector which processes natural resources and the secondary sector which manufactures products but it also includes elements of the tertiary sector such as the retail industry which has a extensive supply chain. Thus the business case for environmental sustainability asserts that by reducing the consumption of resources, companies can improve economic performance through efficiency gains associated with the cost of resources in the short term while also reducing exposure to environmental risk in the long term.

Towards an Integrated Sustainable Enterprise Approach

Current Levels of Sustainability Integration

International industry surveys have suggested that a moderately high level of sustainability integration currently exists within companies. In one such survey 57% of respondents stated that sustainability had been completely or mostly integrated with strategic planning (McKinsey, 2011a). In another survey 48% of respondents stated that their organisation's business model had changed as a result of sustainability (MIT Sloan, 2013). However, it is argued that these industry surveys exhibit a self-selection bias and that they only reveal the current practices in the high sustainability performing megabusinesses which have voluntarily answered these surveys. These megabusinesses are very large companies or larger than large companies that employ at least 2,500 people. This has limit been chosen as approximately 0.1% of American employer firms in 2008 employed at least 2,500 people and it is 10 times larger than the European definition of large companies (U.S. Census Bureau, 2008). Thus, these surveys are not an accurate reflection of corporate sustainability integration in large companies or in SMEs and it is expected that the level of sustainability integration is much lower in organisations of this size. This is supported by a survey which evaluated all of the Finnish companies that produced corporate responsibility reports in 2012 wherein 42% of respondents stated that corporate responsibility was included as an integral part of business strategy (PwC, 2013). It must be pointed out, that only 89 (18%) of the 500 largest Finnish companies produced corporate responsibility reports that year and sustainability is unlikely to be deeply integrated in the 72% of companies that did not produce corporate responsibility reports. This means that the level of integration in the 500 largest Finnish companies is less than 8%. It is a widely held belief that bigger companies are more likely to be aware of sustainability issues. It has been shown that companies with revenues of more than US$50 billion are twice as likely as those with revenues under US$1 billion to report on their corporate responsibility activities (KPMG, 2011). With this in mind, megabusinesses are encouraged to be the early adopters of the innovative environmental strategies that are required to support climate change adaptation.

A key target of this article is to encourage large corporations to embed environmental sustainability into the core of their business, as this is seen as an important way to increase competitiveness and to support climate change mitigation. In order to achieve this target, companies should be directed away from the current trend of short term sustainability. The purpose of the business case developed in this article is to show the tangible economic benefits of environmental strategies with the end goal of increasing the number of companies taking a strategic approach to environmental sustainability.

Focusing on Sustainable Enterprise

Milstein has divided corporate sustainable development into three distinct categories which are defined as follows (Milstein, 2011):

- Corporate environmental management is the effort by firms to reduce the size of their ecological footprint (Bansal, 2005). It is concerned with areas such as environmental regulations and standards, pollution prevention, design to limit environmental impact, environmental reporting and environmental risk management. It requires expertise from departments such as law, environmental policy, environmental health & safety and operations (Milstein, 2011).
- Corporate social responsibility is the serious attempt to solve social problems caused wholly or in part by the corporation (Fitch, 1976). It is concerned with areas such as worker safety, social auditing, philanthropy, community relations and corporate social responsibility reporting. It requires expertise from departments such as public relations, human resources and corporate philanthropic foundations (Milstein, 2011).
- Sustainable enterprise is a way of doing business that makes profits through means that reduce harm to society and the environment (AASHE, 2014). It is concerned with areas such as innovation, entrepreneurship, organisational change and new business development. It requires expertise from departments such as research and design, strategic management and finance (Milstein, 2011).

According to Millstein the core focus of environmental management is compliance with legislation, the core focus of corporate social responsibility is stakeholder communication and the core focus of sustainable enterprise is the creation and optimisation of business opportunities. In these definitions the expectation of environmental management and corporate social responsibility is to keep up with industry best practices in each of the relevant fields. As the focus is on the preservation of operations with regard to industry best practice, these corporate units are not empowered to implement systemic innovations that can significantly improve corporate environmental and social performance. For Milstein the business case for environmental sustainability falls into the category of sustainable enterprise (Milstein, 2011). When aiming to find strategies that result in both environmental and economic benefit it is important that the proposed strategies are not just considered from an environmental management perspective but also from a sustainable enterprise perspective. In order to find innovative long term solutions companies must transition to strategic, systematic, and integrated strategies (Lubin and Esty, 2010). When evaluating the importance of an integrated sustainable enterprise approach for the development of a business case for corporate sustainability the following questions are vital:

- As corporations are spending the vast majority of their corporate sustainability resources focusing on the daily activities of environmental management and corporate social responsibility and should more resources be made available for sustainable enterprise?
- If corporations spend all of their corporate sustainability resources focusing on the daily activities of environmental management and corporate social responsibility does this lead to a short-term approach?

The Key Components of Embedded Sustainability

The concept of embedded sustainability, which shall be defined as the implementation of strategies that are integrated into core business processes is a key element of this article. These strategies are usually generated through a strategic sustainable enterprise viewpoint. Approaches that are not generated strategically are likely to be bolt-on sustainability in which social and environmental considerations are bolted on to existing operations as an afterthought to core business strategies (Lazlo and Zhexembayeva, 2011). Bolt-on strategies are attractive to companies as they involve a low risk of failure, short implementation times and result in low disruption to company operations. However, the disadvantage of this short-term approach is that bolt-on solutions are relatively high cost investments when compared to embedded solutions and they usually only improve performance in the short-term. The allure of quick implementation and low disruption is a result of the multidimensional nature of corporate sustainability, where companies attempt to employ a diverse range of strategies across the social and environmental spheres. It is also a result of companies implementing strategies without being prepared to integrate sustainability into their core business processes. As these strategies are not deeply aligned with the organizations sustainability mission and vision, they can only deliver a small portion of the company's potential performance improvement. Bolt-on sustainability strategies are relevant and it is important that they continue to be developed as the result of conventional operational efficiency improvements however, environmental targets will not be achieved without a greater stress on embedded sustainability. A fundamental shift in corporate environmental policy is required to support climate change mitigation and this will not be achieved through a peripheral short-term approach. Companies are also advised to rationalise their sustainability focus from multiple minor activities to a more manageable number of ambitious integrated innovative strategies. These ecocentric systemic innovations will aim to realign company operations in order to simultaneously improve environmental and economic performance. The key dimensions of bolt-on and embedded sustainability may be seen below in table 1.

Table 1. Key Dimensions of Bolt-on Sustainability and Embedded Sustainability (adapted from Dooley, 2014)

	Bolt-on Sustainability	**Embedded Sustainability**
Implementation time	Fast	Slow
Level of disruption of operations	Low	High
Influence across fields of operation	Narrow	Wide
Investment required	High	Low
Longevity of solution	Short	Long
Risk of failure	Low	High
Reduction in final performance due to losses during implementation	Zero	Zero - Low

Embedded sustainability strategies have the benefit of being achieved through relatively low cost investments, when compared to bolt-on sustainability and they continue to positively influence performance in the long term. However, as the purpose of embedded solutions is to integrate sustainability deep into the company processes, they have the downside of disrupting company operations. This can have negative effects such as productivity reductions due to the time and investment spent on the planning and adjustment to operational change. The innovative nature of these strategies also introduces significant risk of failure and long implementation times. These embedded strategies also have the added benefit of influencing multiple departments within a company's operations such as sales, marketing, research and design, manufacturing and supply chain. One example is replacing glass as the material for food jars with a recyclable plastic that is less expensive to produce, less prone to breakage, less environmentally harmful and is lighter and thus less expensive to transport. This was done by the American food producer Kraft in 2011 and the resulting jar was 84% lighter and one of the products, dry roasted peanuts, required 25% less trucks for transportation (Sonoco, 2012).

The difference between embedded and bolt-on sustainability can be demonstrated by considering transport emission reduction strategies that have been implemented by companies that operate their own logistics fleet. One common example of a bolt-on strategy is the replacement of existing trucks with less emitting models. The replacement vehicle could have higher fuel efficiency or a hybrid, electric or biofuel engine. An example of embedded sustainability could be to revaluate the whole the logistics system and to begin using double-decker trailers (Tesco, 2011). The bolt-on solution enables seamless continuation of company processes as it has a quick implementation time and does not introduce a disruption to operations. The drawback however, is that it requires a high investment cost and eventually the new vehicles will need replacing in order to keep up with advancing technologies. In contrast, the embedded solution introduces substantial operational change as fewer drivers and vehicles are needed, vehicles will be forced to drive at lower speeds and only certain routes will now be available due to height and weight restrictions. Also, the loading of the vehicles will consume more employee resources than was previously the case. However, once the initial disruption has been overcome, the result is a low investment cost, low operating cost and robust solution that substantially reduces transport emissions.

When companies are implementing environmental strategies to reduce their environmental impact they are more likely to implement bolt-on solutions than solutions that alter their operational processes. It is argued that employing the systemic change principles of embedded sustainability can lead to low investment cost and long term solutions that result in substantial improvement in environmental performance.

Discussion, Conclusions and Suggestions for Future Research

In order to be truly sustainable in the long run, companies need to simultaneously satisfy all three dimensions of sustainability, which are social, economic and environmental (Dyllick and Hockerts, 2002). However, in its current form corporate sustainability is not a priority for companies. This is mainly due to the multidimensional and often intangible nature of the discipline. It requires companies to implement a diverse range of actions under limited budgets and this is regularly done without the belief that these actions will bring a direct benefit to the company. Inevitably this scattergun approach frequently produces a diluted end result. In addition, companies are operating outside the limits of natural ecosystem balance and a fundamental shift in operating policy will be required to meet future governmental climate change targets. With this in mind, this article advocates a temporary shift towards environmental strategies with the aim of reigniting the flame of corporate sustainability.

The key target of this article is to encourage companies to substantially increase the resources that they dedicate to sustainability by demonstrating the economic benefit that can be derived from it. The aim is to raise the economic credibility of sustainability in order to significantly increase investment. It is argued that the economic performance can be optimised through sustainability by (a) focusing on strategies that have a direct business case, (b) rationalising sustainability investments and (c) integrating sustainability into the core of the company's business processes.

Relative to social actions, the resulting economic benefits of environmental actions are more tangible and thus have a direct and clear business case. For this reason environmental actions are preferred to social ones when implementing strategies to revitalise corporate sustainability. The profitability of environmental strategies is also expected to increase over time due to environmental risks posed by resource scarcity and the necessity to combat against climate change. The streamlining of sustainability strategies is advocated and it is argued that they should be divided into two categories. The first category requires companies to maintain the minimum best standards of social and environmental governance and the second category involves the implementation of a manageable number of ambitious environmental policies. In order to maximise the potential economic benefit and environmental impact reduction the implemented policies should be aligned with the company's core business strategies. A high level of sustainability integration will be referred to as embedded sustainability. Once economic success has been achieved through the first wave of environmental initiatives it is expected that corporate support for sustainability will amplify and that this will result in increased investment in both the social and environmental dimensions.

The observation has been made that companies can raise the economic credibility of sustainability through the adoption of ambitious environmental strategies. Further research is required to convince companies to overcome the inertia of business as usual and to implement the aforementioned environmentally focused systemic innovations. This will involve the publication of successful case studies, business models and guidance to governments regarding potential public policy instruments. Past research should be built upon. Academics have claimed that governments cannot rely purely on market forces to deliver the transition to a resource efficient society. Although resource prices are starting to go up and this is changing behaviour and inducing innovation, it is not happening fast enough and public intervention is needed (Zenghelis, 2013). Other researchers have argued that climate change mitigation targets will not be achieved without the imposition of carbon taxation (Rogelj et al., 2013). Also, feedback from public policy instruments designed to encourage corporate environmental management have been published in order to assist future policy (Valentine, 2012).

Recently the intergovernmental panel on climate change has called for increased research "on the relationship between incremental changes and more significant transformations for sustainable development". Within this research the "benefits, costs, synergies, tradeoffs and limitations of major mitigation and adaptation options" has been prioritised (IPCC, 2014). Further analysis on the relationship between bolt-on and embedded sustainability and the business case for embedded sustainability would fulfil this call for future research.

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ARCTIC FUTURES 2033 – OPPORTUNITIES AND THREATS FOR SUSTAINABILITY

Governing Change towards Sustainable Economy in the Arctic

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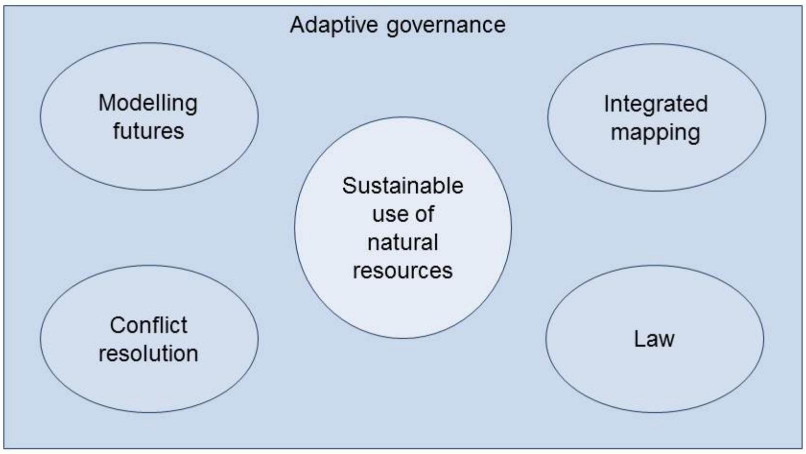
The Arctic region has recently gained increasingly attention due to predictable significant changes, which are relevant at global, regional and local levels. The key drivers of changes are the climate change and new economic opportunities. They are partly combined, partly separated. Climate change may open new economic opportunities (and destroy old ones) and responsible use of these opportunities is particularly important in the fragile – and changing – Arctic natural environment. In economic terms, a key driver shaping the future of the Arctic is the development of extractive industries. For example, recent international evaluation have placed Finland as the globally most favoured country for targeting mining operations (Wilson et al. 2013) and these operations remain focused on the northern and eastern parts of the country. Large-scale mining may negatively affect other livelihoods which depend on green infrastructure, such as tourism, forestry and reindeer herding. The tension between livelihoods calls for approaches that are able to support change towards sustainable economy in an adaptive fashion. Such an approach needs to contain knowledge-based tools for informed and balanced decision-making as well as development of social institutions able to govern the change. In this scoping study we outline key elements of a new approach, which could support governance of foreseeable transition in the Arctic

Background

A key driver of economic transition in the Arctic is the growing importance of the extractive industries. The Arctic is one of the largest remaining frontier regions on the globe and is regarded as a vast storehouse of potential mineral resources. Recent international evaluations have placed Finland as the most favoured country for targeting mining operations globally (Wilson et al. 2013), with the interest in mining operations focused on the northern and eastern parts of the country (Eilu 2012). The mining industry in Finland is one of the rare industrial sectors that is growing and currently targeted by considerable foreign investment. In the Finnish Arctic, another rapidly growing economic sector is tourism and forestry is still the largest sector in the region. In the Finnish Lapland mining industry is currently creating the greatest change and challenge in the economy and land-use in this region. In contrast to other natural resource based industries in the Finnish Lapland such as forestry and tourism, mining industry does not growth gradually but in discrete steps as new mining sites are opened. The new mining operations are typically quite large compared with the local economic activities in these rural areas imposing many challenges for governmental decision makers and land use planners. Furthermore, competition among land use interests related to mining, other livelihoods and environmental protection is likely to intensify in the future (Eerola 2013), and the conflicts this may engender could threaten sustainable growth. Achieving balanced development between different land uses and sectors of the economy – development that supports the needs of both society and business – will require strengthened reconciliatory capabilities of enterprises as well as of governmental and community organisations.

In sustainable economy, resources are used in the best possible way for the purpose of achieving responsible and balanced benefits over the longer term. While achieving and determining fully sustainable economy may be challenging, sustainability can be understood as an adaptive process that calls for reflexive governance (Kemp et al. 2005). Theories of reflexive governance, like theories of adaptive management and transition management, analyse socio-ecological and socio-technical systems to provide insights into how to manage dynamic change. They stress collective experimentation and learning (Voss and Bornemann 2011). Hence, reflexive and adaptive governance that is able to ensure sustainable growth requires that we both strengthen the relevant knowledge base, and improve social institutions.

To respond to this challenge, multidisciplinary research concept is needed that integrates different kinds of scientific approaches with the aim to provide new tools for adaptive governance. This paper can be regarded as a scoping study for such kind of conceptual framework. We suggest a multidisciplinary framework in the spirit of adaptive management (see figure 1), which consists of four interlinked topics, namely 1) modelling future use of natural resources, 2) integrated mapping, 3) adaptive law and 4) conflict resolution (Figure 1). The two first topics aim to strengthen the knowledge-based of decision-making, while the two others aim to improve formal and informal social institutions, which frame decision-making. Modelling future use of natural resources provides an understanding of the coming challenges, whereas integrated and spatially explicit assessment of the economic, social and environmental values associated with alternative uses of resources is critical for sustainable management of natural resources. Rigid legal rules may hamper the full use of information provided by scenarios and integrated assessment and hence the legal structures should be made adaptive and reflexive. While knowledge-based tools give common information basis and adaptive legal structures allow new decisions, conflicts may still emerge. Hence, governance model should also pay attention to conflict resolution practices.



Multidisciplinary assessment framework for the sustainable use of natural resources in changing Artic region

Material and Methods

Modelling of the possible future use of natural resources, or in other word, studying the potential for well-being, economic or recreational, that these resources could provide in the future, should be a core part of long-term land-use planning. The availability and life-span of the resources can vary based on their capability to renew but also they can provide multiple functions for people ranging from recreational forests and landscapes to economic utilization. The key question in land-use planning is to reconcile the different functions together by a meaningful way which could, however, not always be straightforward or easy to define due the contradicting human values over places and their main functions. Institutions are keys in resolving value-conflicts in the sense that they give people opportunities to articulate their values in participatory processes. Focusing on institutions and the process of institutionalisation can help to clarify how it is possible to solve value-conflicts over land use in practice.

Modelling futures of the natural resources use

In this research we focus to model especially the future development potential of the mining industry in Finnish Lapland, as this branch is currently creating a change in the economic structure in the region. Modelling will be based on the knowledge over existing mineral deposits on the region, estimates about the currently unknown resources and characterization of the mineral deposits. The modelling will be made for several development scenarios. Earlier approaches to model mining futures vary from visionary works driven by (geo)politics (e.g. World Economic Forum 2010) and broad visions (Finland's Minerals Strategy 2010; Mason et al. 2013, 2011) to global trajectories including quantitative regional and/or global models (e.g., Giljum et al. 2008), system dynamic modelling reflecting differing societal perspectives (e.g., van Vuuren 1999;) and estimates of possible peaking of the mineral resources (e.g., Northey et al. 2014). In this project we develop a regional mining model based on earlier scenario work made for Finland (Tuusjärvi et al. 2014). The aim is to combine global factors driving mineral markets with factors affecting mining activities on a national and local level.

In general, mining projects can differ significantly depending on mine type, ore type, processing method and plant design. These factors, together with the corporate culture of the operating company, conditions in the local community and the industry's track record in the region largely define the economic and environmental impacts a mine will have on its surroundings, and partly determine its potential social impacts as well. The research on the corporate social responsibility of mining companies (e.g., Prno and Slocombe 2012) and on the relationship between industry and government (e.g., Waye et al. 2009) provides insights into the role of socio-ecological factors.

Integrated mapping

Integrated and spatially explicit assessment of the economic, social and environmental values associated with alternative uses of (land) resources is critical for sustainable management of natural resources (Bateman et al. 2002). Spatially explicit units are needed to quantify the effects of alternative uses of natural resources because supply and demand for these alternatives are spatially explicit and may differ geographically. Hence, mapping is a useful tool for illustrating and quantifying the spatial mismatch between supply and demand and can be used for communication and to support decision-making (Crossman et al. 2014). For sustainable use of natural resources, there is a need for good understanding of what advantages or disadvantages are provided by the use of natural resources in a given piece of land.

Mapping has increasingly been used for ecosystem service assessment (see for example Crossman et al. (2014) for a recent review). A large number of recent studies have mapped the supply of multiple ecosystem services at different scales (Naidoo et al. 2008, Nelson et al. 2009, Willemen et al. 2010, Bateman et al. 2011, Schulp et al. 2012, Strück et al. 2014), but studies considering the demand site are not that common (Burkhard et al. 2010, Kroll et al. 2012, Nedkov and Burkhard 2012). Frameworks integrating ecological and economic aspect have emphasized the assessment of monetary values of ecosystem services (de Groot et al. 2010, Wainger and Mazzotta 2011). In addition, activities to collect spatially explicit socioeconomic information using Public Participation GIS (PPGIS) methods are also rapidly increasing (Brown & Kyttä 2014). Location-based information from people supports context-sensitive management of natural resources, which can reduce conflicts and increase the social acceptability of mining and other development projects. Biodiversity is crucial for the providing of ecosystem services such as timber, carbon sequestration and recreational services and hence it is a key indicator to be evaluated together with economic and social indicators in resource use planning. So far, little evaluation on the relationship between biodiversity and people's opinions has been carried out in PPGIS studies however (but see e.g. Brown & Weber 2011).

We suggest the development of an integrated GIS-based mapping approach that takes into account ecological, economic and social aspects of the governance and use of natural resources. In order to evaluate the needs and possibilities for adaptive coordination of land uses such as mining, forestry and tourism, it is useful divide the selected study area into sections for which the ecological, economic and social values can be assigned. The simultaneous assessment of the values of different sections allows for their categorisation into different classes according to their suitability for different land uses. The process which consists of data compilation and integration, identification of overlaps and potential conflicts, and categorisation of sites into different alternative land-use classes – forms an operations model that supports sustainable management and use of natural resources.

Adaptive law

One of the key functions of law is to ensure predictability and security (Garmestani et al. 2011), without which economic actors may be unwilling to invest and plan long-term activities. The flip side of this is that law may become rigid and unable to support adaptive change. Law may hamper the use new information provided by knowledge-based tools and resist changes suggested on the basis of the information. As a response to this dilemma, lawyers have started to develop adaptive law (Crag and Ruhl 2014), which aims to make possible adaptive management of natural resources. Even earlier, the concept of ***reflexive law*** was introduced as a response to the criticism of the interventionist state (Teubner 1983). The continued expansion of rationalist, bureaucratic regulation was seen exhausting and costly, and potentially reducing the "viability of informal, culturally grounded understandings as the basis for societal self-regulation and cohesion" (Zumbansen 2008).

The demand for more reflexive and adaptive regulation has gained momentum as a response to deal with scientific uncertainty, economic, social and political risks due to uncertainty of social and natural conditions, and dynamic and complex nature of socio-ecological systems (Ruhl 2011, Ebbesson and Henley 2013, Hildén and Similä 2007). Also from technological development point of view, too rigid regulation has been considered problematic (Similä 2002, Hildén et al. 2002). In short, good governance of foreseeable change of socio-ecological systems in the Arctic requires such law, which is able to supports or suppresses producing and gathering information, communication and balanced reaction to new information and outcomes of communications. Despite rising attention to adaptive law in theoretical research, it is not yet clear how reflexivity in regulation can foster and consolidate transitions and how current legal structures, concepts, principles, rules and processes affect possibilities to achieve reflexivity. Hence, it is essential to explore how to improve law's adaptive capacity.

Adaptive law has many attractive features. However, it is not a cure for all. There are limitations which relate to practical, political and normative issues. The idea of adaptive management to go forward through experimenting (learning from small steps and using lessons learned to guide the further steps), is not necessary the right way to make decisions on large-scale infrastructure decisions, like railroads, where corrected action already made would be very costly. Also lack of monitoring mechanisms may make the use of adaptive approach meaningless. New decisions need new information. Because monitoring and iterative decision-making may be costly, insufficient political support may result insufficient financial resources, and finally hamper the implementation of true adaptive approach. Furthermore, some environmental consequences may be considered so risky that the legislator does not allow any kind of experimentation. A result from this would be a normative limitation to the application of adaptive approach. (Craig and Ruhl 2014). Furthermore, the design of adaptive law must be done carefully and include various checks and balances, because adaptive law approach may result in decentralisation of power, which, in turn, may affect how the benefits for local economies and global goods (like biodiversity) are balanced in decision-making.

Conflict resolution

Participatory governance designs, such as co-management regimes, could form part of the Arctic's adaptive capacity, that is, its ability as a socio-ecological system to adjust to internal and external changes without sacrificing options for the future (Carpenter & Brock 2008). However, a number of difficulties have been noted in collaborative planning, in particular its limited capacity to deal with power relations, resistance, political action and access to decision-making processes (Collier & Scott 2009). In Finland, the Land Use and Building Act demands that all parties involved should have a say in big land use projects although e.g. social impact assessment is not clearly required (Kokko et. al. 2013). In addition, other, more voluntary-based, participatory practices are often implemented. However, these participatory practices have some problems. Firstly, the crucial issue is who defines what kind of knowledge is needed and collected. Secondly, it is important to notice who are the parties involved and who decides who the relevant parties are. Thirdly, not much attention has been paid to the question of how the collected knowledge is used in actual decision-making.

A good illustration of the problems and possibilities of participatory practices is the case of the use of state forests in upper Lapland. Metsähallitus, the state forest administrator, has applied participatory management tools in order to resolve the conflicting issues between reindeer herding, forestry and nature conservation. However, critics claim that this has not been successful due to distrust between parties (Raitio 2008). Mustajoki et al. (2011) have applied decision analysis interviews in the same case and have noticed that the approach works well but it has to be tightly integrated into the planning process. Similarly, in relation to mining plans it has been noticed that the timing of collaboration is crucial as well as the continuity of participatory practices (Kokko et al. 2013).

Mediation in solving environmental conflicts has not been used much in Finnish context. The Finnish planning law does not recognize any systematic procedures, methods or practices specifically designed for conflict resolution, and conflicts are addressed through the emphasis on communication and public engagement (Peltonen & Sairinen, 2010). However, mediation practices are more and more demanded also in Finnish context. This was the case, for example, in the forest dispute in upper Lapland as the researchers were asked to mediate in addition of doing research.

Discussion and conclusions

The socio-ecological systems of the Arctic are likely to experience significant changes in coming years. The change will be relevant locally, regionally and globally and it requires special attention, because of fragile natural environment, significant increase of temperature due to climate change, and sensitive societal structures with indigenous people in the Arctic. In economic terms, extractive industries and new transport opportunities are key drivers shaping the future of the Arctic. Large-scale extraction projects increase the energy use and emissions of greenhouse gases, and they therefore have a long-term impact on Arctic nature. Mitigation measures and new extraction techniques are needed to halter this negative development. Mining provides welfare to local people and supports the economic viability of rural areas, but it can also trigger long-lasting conflicts among local population, non-governmental organisations, industries and the state, including both supportive and defeating arguments towards projects. For example in the case of Finnish Lapland, mining is likely to be a key economic driver due to the combination of expected long term resource demand from emerging economies and substantial mineral potential of the region. In other Arctic regions driver(s) can be another type of extractive industry or fully different kinds of economic activity. The development of mining industry has a multifaceted impact on the future of the Arctic in Finnish Lapland not least due to effects to the other livelihoods dependent on the natural resources and green infrastructure, forestry, tourism or reindeer herding. Scientific uncertainty, economic, social and political risks, and the dynamic and complex nature of socio-ecological systems associated to the change call for development of governance structures. These structures should produce new knowledge about coming changes and be able to use this knowledge to give a new direction when needed.

Adaptive management provides a fruitful starting point for the development of governance structures – and research supporting this governance. The principles of adaptive and reflexive management are appealing in the context, where a significant transition seems evident. The emphasis of governance structures should be on learning, reflection, and adaptation. Law as a social institution is likely to have an important (positive or negative) role in adaptive governance, although adaptive management theorists have only recently started to pay attention to law.

Rapid economic change can be seen as a disturbance to current socio-ecological system in the sense that it may cause many undesirable and unpredictable consequences in addition to the positive objectives it explicitly aims to achieve. As mentioned above, mineral extraction in the Arctic may adversely affect – apart from natural environment - other livelihoods, especially those that depend on green infrastructure, such as tourism, forestry and reindeer herding. The core of the concept of green infrastructure is an understanding of the natural environment as infrastructure capable of delivering a wide variety of essential ecosystem services (Frischmann 2012). The governance challenge is not to eliminate all disturbances (like rapid economic changes), but to govern the transition caused by disturbances from current state of socio-ecological system to new one in a legitimate way.

The complex nature of socio-ecological systems calls for multidisciplinary research approaches combining various disciplines and supporting governance of transition. While it would be impossible to give an exhaustive of research fruitful topics, we can summarize the topics of research we consider particularly important as follows (see also figure 2):

- Modelling future use of natural resources with their social and environmental implications
- Development of tools, which support integrated mapping of economic, social and environmental values
- Improvement of adaptive capacity of law by seeking a sustainable balance between predictability and ability to make a change. This may happen by providing new concepts, approaches and evidence of the functioning of law.
- Development of new conflict resolution practices though experimental research on mediation

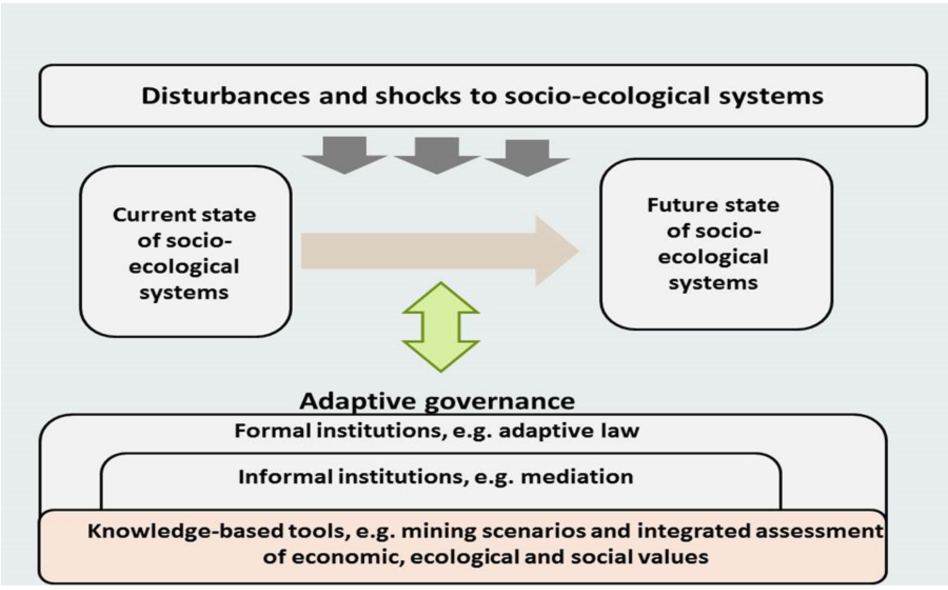


Figure 2: Adaptive governance and change of socio-ecological systems.

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Factors Affecting Women´s Land Tenure in Namibia

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Land tenure in Namibia is divided into private commercial ownership and communal land tenure. Women seldom own land even though they take care of 90 per cent of the cultivation in communal land areas and produce most of the food. With unsecure land rights and limited opportunities for earned income, women have less capacity to invest in improved conservation practices. Thus, the effects of climate change can be mitigated by improving women´s land tenure rights. This study examines the factors affecting women´s land tenure in Namibia; the study is based on a literature review. According to earlier studies, cultural and social norms and customs are the most significant factors that restrict women's land tenure. The lack of education also affects women's land tenure strongly. Rural women, especially, are often unaware of legislation affecting their rights. The resettlement and land distribution programs, supported by the government, are not considered effective enough in promoting women's land tenure rights. It would be possible to mitigate the effects of climate change indirectly by developing and monitoring land laws and reforms in order to make progress in women´s land tenure in Namibia's rural areas.

Keywords: women, land tenure, climate change adaption, Namibia

Introduction and Background

Climate change creates a challenge for global food production and security. Especially developing countries are estimated to be severely affected by the climate change. It causes changes in natural ecosystems, land capacity and land use systems and also affects structural issues, e.g., tenure security, land redistribution and land use regulation (Quan & Dyer 2008). In turn, land tenure problems are considered as important contributors to poverty through reducing livelihood opportunities and compounding food insecurity (FAO 2002).

The agriculture in sub-Saharan Africa, especially, is very sensitive to climate change as the resulting volatility increases poverty (Ahmed et al. 2009). Due to poverty, rural households have a lower mitigative and adaptive capacity (Lambrou & Piana 2006). However, Hertel and Rosch (2010) emphasize that these countries have a great potential to contribute to mitigation of climate change through agricultural practices. Climate change will not only affect land tenure but also the opposite is true, when secured land tenure rights can facilitate adaption to climate change and mitigate its effects (Quan & Dyer 2008). Secured land tenure rights are therefore one key to food security and climate change adaption: as a land owner, a person has permanent place of residence and thus he or she has more interest to invest in the land and in environment friendly techniques (Barbier 1997; IFAD 2008; Nkonya et al. 2008; Tenaw et al. 2009).

In developing countries approximately 10 to 20 per cent of all landholders are women (FAO & CGIAR 2013). Men's and women's access to agricultural resources, such as land, is often unequal. Governance of these resources, however, is crucial for adaptation to climate change. According to Angula (2010), adaption to climate change is a social issue and crucially asks for policy intervention. For this reason, more attention has been paid to women's land tenure rights in developing countries during the last decade and organizations like UN, FAO and World Bank have highlighted its importance in many forums.

The female share of agricultural labour force is almost 50 percent in sub-Saharan Africa and women play a key role in food production. Women are less likely to own or have access to land than men, however, and they comprise only about 15 per cent of all agricultural holders (owned, rented or allocated) in sub-Saharan Africa. In addition, due to social, cultural and economic constraints, land areas held by women are often of a poor quality and in small plots, which leads to low productivity (FAO 2011a; IFPRI 2005; World Bank 2008). FAO (2011b) calls this "sub-Saharan phenomena", referring to women who are overrepresented in unpaid, seasonal and part-time work and paid less than men for the same work.

Namibia is one of the sub-Saharan African countries where land tenure issues have received a lot of attention during last decades. Women are responsible for up to 90% of the subsistence crop production in Namibia, but their lack of access to resources limits their economic choices and causes economic dependency on men (ADP 2007). Namibian land tenure issues have been examined in several studies and part of them focus on women´s land tenure rights from different perspectives (e.g., social and cultural norms, legislation, HIV/AIDS).

The government of Namibia has identified land degradation as a serious problem which requires long-term intervention. In Namibia, various sectors – agriculture, land use and water, for example – are vulnerable to climate change. People do not often acknowledge how their natural resource use can increase land degradation. Climate change will affect particularly women and their livelihoods in rural areas (Akhtar-Schuster et al. 2003; Angula 2010; Ron 2011; Ron 2012).

As the effects of climate change can be mitigated by improving women´s land rights, the objective of this paper is to conceive factors affecting women´s land tenure in Namibia. The examination is based on a literature review and factors explaining women's land tenure are presented in the next section. In the findings section, the most significant factors affecting women´s land tenure in Namibia are discussed in more detail.

Land tenure and women's rights in Namibia

Namibia became independent from South Africa in 1990, when also the political system of apartheid ended. However, the politics of South Africa had a great influence on Namibian land tenure rights and agricultural sector during the 1900's and agricultural policies of Namibia were often tailored to serve the interests of South Africa. Farmland was distributed/divided to landless whites who mainly focused on beef production. Even today, 38% of the land is used for cattle ranching (Mendelsohn 2006).

At present, Namibia is among most developed countries in sub-Saharan Africa and classified as a middle-income country on the basis of average income per capita (World Bank 2014). The classification, however, is quite misleading as the country's income distribution is very unequal.

Namibia is less urbanized than other sub-Saharan African countries and 70 per cent of the population (2.3 million in 2013) lives in rural areas where poverty prevails (IFAD 2010; World Bank). About 78% of the territory is used for farming and farming employs most of the population. However, only 46% of the households living on farmland obtain their incomes mainly from farming (Harring & Odendaal 2007; Mendelsohn 2006).

Land tenure rights

There are three land tenure categories in Namibia (Table 1). Before national independence, land in tribal areas was owned by the state and it was called homelands. At independence, homelands were immediately renamed as communal land. About 36% of Namibia's total land area is communal land, including communal open access farming and communal exclusive farming. Communal farmers typically have tenure right to small areas that surround their houses. Communal land cannot be sold or mortgaged and it is controlled by traditional authorities, who allocate usufruct rights. This means that farmers don't have permanent or legal land tenure rights, which reduces their incentives to develop the value of land (ADB 2007; Mendelsohn 2006; Mendelsohn et al. 2012).

About 43% of total land area is freehold land for commercial farming. Only 5% of Namibian population lives in commercial land areas that are mostly located in central Namibia. Most of the free-holders are white (Harring & Odendaal 2002; Mendelsohn 2006).

Table 1. Land tenure categories in Namibia (ADB 2007; Harring & Odendaal 2007; Mendelsohn 2006; Sweet & Burke 2000)

Land tenure type	% of territory	% of population	Major production sector
Commercial farmland with freehold tenure	44	5	Animal husbandry
Communal land	36	50	Rain-fed mixed crops (e.g., sorghum, millet, maize, wheat)
State land (incl. conservation areas, urban areas)	20		

After independence, attempts have been made to get rid of the duality of land ownership by changing legislation and by making reforms (e.g., The Agricultural Land Reform Act 6 1995, The Communal Land Reform Act 5 2000). Different programs, such as The Resettlement Programme and Affirmative Action Loan Scheme (AALS), have been created to resettle landless households. Resettlement farms, however, comprise just about one per cent of country's total land area (Mendelsohn 2006; RoN 2001). AALS is a land reform tool, which since 1992 has enabled new farmers from the previously disadvantaged communities to acquire farms in commercial areas. AALS-programme, however, is not specifically targeted at women (Harris & Odendaal 2002; UN-Habitat 2005).

Based on the adapted tenure categories, Namibia's agricultural sector is divided into two major parts: the commercial sector and the communal sector (Harring & Odendaal 2002). The *commercial sector* is privately owned and largely controlled by the white minority. The *communal sector* in cattle production includes communal open access farming and communal exclusive farming. In the first alternative, farmers use open access to graze on communal land. Communal exclusive farming refers to farms that have been fenced off into exclusive ranches in communal areas (Mendelsohn 2006).

Women's rights and land tenure

The constitution of Namibia states that all persons are equal and no one shall be discriminated due to gender. Legislation has been amended as an attempt to reduce women's dependence on men. For example, all Namibians can apply for a monthly pension at the age of 60 years and women are entitled to maternity leave benefits. During the last decade, many policies have aimed to increase the share of women in the political field. Proportion of seats held by women in the current national parliament (term 2010–2014) is 24 per cent. Representation of women has been more equal in local governments (ADB 2006).

There are two types of marriage in Namibia; a civil marriage and a customary marriage. A civil marriage is contracted in a church or in a magistrate while customary marriage takes place in terms of the customs of the community. The customary marriage is extensively appreciated in rural areas. The challenge of customary marriage is that possible problems (e.g., divorce) are solved by the community which often favors men (LeBeau et al. 2004a).

About 44 per cent of Namibian households were headed by a woman in 2007. The number is high as compared to most of SSA-countries and it is caused not only by divorce or death of a partner but much by the choice of lifestyle (ADP 2006). One important reason to this relatively high number of female-headed households especially in rural areas is that men travel more often to urban areas in search for a job (Mendelsohn 2006). Despite of this, women are not making decisions in the households. LeBeau et al. (2004a) describe a situation, in which a woman is not directly or indirectly under the men's authority, as very rare in Namibia. In most Namibian communities there is a person who is called a chief or a headman. These traditional leaders are almost always men and they manage allocation of land and natural resources although communal land is being owned by the government.

Women-headed households are poorer than the average household and they are more likely dependent on subsistence agriculture (Iipinge & LeBeau 2005). Because women more often than men live in rural areas, lack of infrastructure affects especially women. Rural women have many household tasks besides cultivation, which restricts their transition to cash crop production, inter alia. HIV/AIDS epidemic increases the burden of rural women and reduced labour input causes damage to agricultural sector. According to Unicef Statistics (2014), the prevalence rate of HIV/AIDS among adults was 13.3 per cent in 2012 and majority of those carrying the sickness were women. Women who die for AIDS are 5–10 years younger than men (ADP 2006; UNWOMAN 2013).

Factors affecting women´s land tenure

According to previous studies, several factors affect women´s land tenure in Namibia. A number of studies have examined women´s land tenure rights from some particular perspective and many of the affecting factors are related to each other (see Figure 1). Due these linkages, the listing of affecting factors is not unambiguous. However, different factors affecting women´s land tenure are examined next. Since women's land ownership is a specific problem of communal lands, the discussion will be focused on this case.

Political reforms and legislation

There is some evidence that political reforms and legislation have increased women's access to land in many communities (Thomas 2008; Werner 2008). Eviction of widows from their land has reduced since the 1990s because headmen are informed of the legal rights of widows and the risks of ignoring them. According to LeBeau et al. (2004b), far more men than women know about legislation promoting women´s rights and many have found out about it through other men. Despite this awareness, the property law is being further violated in many communities and traditional leaders, neighbours and police may ignore such violations (Harris & Odendaal 2002; Lebert 2005).

Obviously, despite the legal and social reforms, there are still several legal factors that constrain women´s land tenure (LeBeau et al. 2004a). Customary law is probably the biggest challenge. It should follow the common law in property matters, but customs often vary between communities. This increases the decision-making power by traditional leaders. In the case of customary divorce, wife receives little or none of the marital property in most Namibian communities. Most of the customary courts are occupied by men and women are not always allowed to attend (LeBeau et al. 2004a).

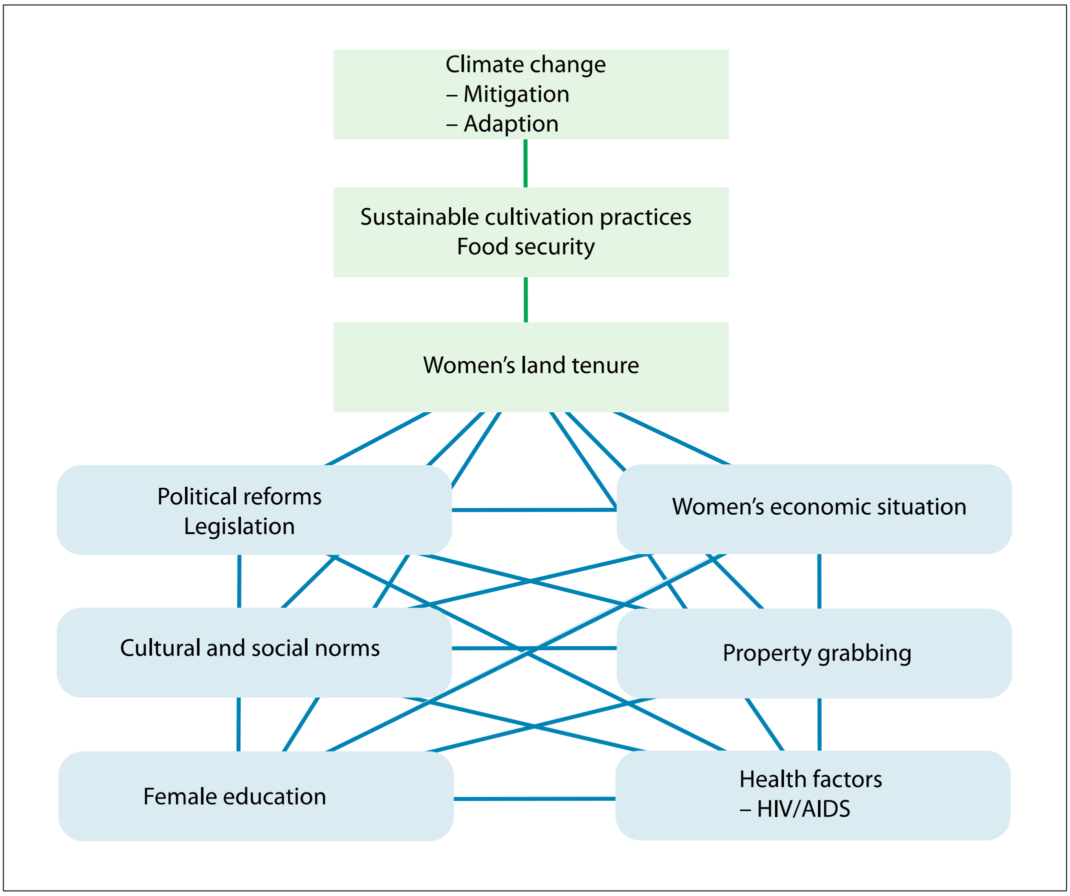

Figure 1. Key factors affecting women's land tenure in Namibia and link to climate change.

Cultural and social norms

Cultural and social norms restrict women´s land tenure in Namibia. The norms include several customary practices that restrict women´s access to land. Traditional leaders still control and allocate land and they are typically men in the Namibian culture. In order to follow the traditions, land is typically allocated to the husband. Unmarried women, in turn, have access to land through their fathers (ADB 2006; Hubbard 2012; Iipinge & LeBeau 2005; Jauch et al. 2009; LeBeau et al. 2004a; Werner 2009). Widows are finding it most difficult to hold on to their property rights because they often experience socio-cultural pressures and lack the support of husband's relatives in inheritance issues (Lebert 2005; Thomas 2008).

In some communal areas, the traditional authorities have demanded illegal payments from women in granting access to communal land or from widows in reallocation. There are also cases where women have not received any land. Grazing, in particular, is seen as men's work and many traditional leaders still refuse to allocate land to women for grazing (Acheampong 2011; Lebert 2005; Werner 2008).

The number of reported cases of violence against women has increased (Hubbard 2008). Iipinge and LeBeau (2005) remind that sometimes gender specific law reforms may actually cause gender-based violence against women because all men do not regard women´s rights as a good thing. The authors emphasize that discriminatory attitudes of men are the biggest obstacle to achieving gender equality. Therefore, changes in social and cultural reality are crucial to improve women´s rights and, consequently, increase their land ownership.

The phenomenon of "***property grabbing***" has become more frequent in recent times. The term refers to a situation where the deceased husband's family members take all of the property from the widow. Property may include movables, land or other fixed property. This phenomenon may happen physically or in indirect ways, e.g., witchcraft (LeBeau et al. 2004a; Werner 2008). The present legislation aims at reducing conflicts from land grabbing. Even if women's land rights are secured, their livelihood weakens if they loose their other property. In this case, there is a risk women have to give up the land that is unproductive without vital resources, e.g. production inputs (Hubbard 2008; Mandimika & Matthaei 2013).

Women's economic situation

Women´s economic situation also affects women´s land ownership, and vice versa. Stable economic situation allows women to purchase land and land tenure rights, in turn, allows more stable income (ADB 2006; Iipinge & LeBeau 2005). Land ownership also improves access to credit in commercial land (Mendelsohn 2006). However, land in the communal area cannot facilitate access to credit. This is mainly due to insecure land rights, while financial institutions are reluctant to accept land as collateral security (Kaakunga & Ndalikokule 2006).
It is difficult for women to get credit to purchase land due to lack of own property. However, women´s commitment to repay their loans is higher than by men´s in Namibia. Defending one's land tenure rights may also require economic resources, which is challenging for poor rural women (Tonin et al. 1998).

Education

Lack of education restricts women´s land tenure rights. At the time of independence, general levels of literacy were at 30–35 per cent in Namibia (Marcus & Baden 1992). Due to poverty, many children are excluded from education because they cannot afford school fees. Girls are first to drop-outs when financial constraints are effective (ADB 2006). LeBeau et al. (2004a) emphasize that highly educated women are more aware of their inheritance rights. Often women do not utilize their legal rights because they necessarily do not know their rights or do not understand the content of the law (Iipinge & LeBeau 2005; Werner 2008).

Lack of education and knowledge also enhances land degradation, because people at this situation do not acknowledge how their natural resource use could have negative effects on soil (Akhtar-Schuster et al. 2003).

HIV/AIDS

HIV/AIDS epidemic makes infected women weaker to defend or demand their rights. Property grabbing is more general in households affected by HIV/AIDS. According to Economic Commission of Africa (2004), there is a tendency for those living with HIV/AIDS to be excluded from land programs due to the effects illness; they may also loose already acquired land due to illness. In some regions, once the husband dies for AIDS or HIV related illnesses, his relatives may force the widow to leave the homestead. There have been some cases, where the widow´s house has been burned down (FAO 2003; Fuller & van Zyl 2006; Werner 2008).

Productivity generally decreases in rural households affected by HIV and AIDS and these households may start to suffer from hunger and malnutrition (FAO 2003; Fuller & van Zyl 2006). In some communities, the stigma attached to HIV/AIDS can directly influence the well-being of the household. Due to the stigmatized nature of AIDS, HIV-positive people do not necessarily seek medical care (Thomas 2006).

Findings and Discussion

This literature review on women´s land tenure rights in Namibia showed up that factors affecting women´s land tenure are not unambiguous but rather form a complex set of interlinked factors. For example, educational level of women affects their awareness of the legislation, which in turn influence their attitude towards traditions. However, the most significant factors that were identified in the study are discussed next.

According to earlier studies, cultural and social norms and customs are the most significant factors that restrict women's land tenure rights. Women don't have equal decision-making power within households and communities. Despite formal legislation and several reforms, land is considered as men's property in many communities. Traditional leaders have a key role in promoting the land tenure of women. They are aware of women´s rights, but there have still been cases where traditional authorities have refused to allocate land to women or have demanded illegal payments from women in granting access to communal land.

While discriminatory attitudes of men are an important cause in not achieving gender equality, changes in the social and cultural norms are crucial to improve women´s rights. Due to this, land laws and reforms should be developed and monitored in order to make progress in women´s land tenure in Namibia's rural areas. According to Akhtar-Schuster et al. (2003), the existing communal land tenure system does not sufficiently take into account the land carrying capacity when allowing free grazing and the accumulation of livestock. As Harring and Odendaal (2002) have proposed, Namibia needs a clear agricultural development policy.

Girls' education is a significant factor in increasing women's land tenure. Highly educated women are aware of their inheritance rights. Poorly educated women do not utilize their legal rights, because they do not know their rights or do not understand the content of the law. In addition, higher education often improves the economic situation of women, when their economic dependence on men decreases.

In the case of Namibia, the HIV/AIDS epidemic must be observed. The epidemic damages the situation of women affected by HIV further and their access to land becomes even more difficult. Property grabbing is general in households affected by HIV/AIDS and widows have been evicted from their land.

As Namibia is situated in one of the high risk areas with regard to climate change (Macchi 2008), it is crucial to find methods to mitigate the effects of climate change. Gender issues have not played a major role in the climate change discussion (Angula 2010). Land degradation – is a serious problem in Namibia – can be reduced through secured land tenure. As women's land tenure is low compared to men, effects of the climate change can be mitigated by increasing women's land tenure rights.

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Initial Designs of a Photovoltaic PEM Electrolysis System for the Production of Hydrogen for Domestic Cooking

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The preparation of meals is an essential part of everyday human life; however the continuing increase in the cost of energy is making this essential task more and more difficult from an economic perspective. This is most evident in developing countries but it is also widely accepted that the current rate of usage of fossil fuels for essential purposes is unsustainable, so as time goes by this problem could also become pervasive in some socioeconomic sections of developed countries as well. The problem is further compounded by the substitution of trees for cooking fuel which causes widespread deforestation that worsen the effects of climate change. This paper presents the initial research and design of a system for the production of hydrogen from sustainable solar power and the necessary technologies for its safe and reliable use for domestic cooking. The photovoltaic and polymer electrolyte membrane (PEM) electrolysis system design is presented as well as a working roadmap and current progress in establishing parameters and developing technologies necessary for the safe storage, monitoring, control and burning of hydrogen gas for everyday cooking in the home.

Index Terms: Hydrogen, PEM Electrolysis, Photovoltaic, Sustainability, Climate Change

Introduction

Throughout the world various energy sources are used to provide the heat necessary for cooking. These energy sources include electricity, fossil fuels such as liquefied petroleum gas (LPG), natural gas or coal and renewable biomass such as wood, charcoal and animal dung. The energy source used is normally determined by the socioeconomic status of the specific country or region and also by demographics in a particular country. Predominantly richer more developed countries with higher socioeconomic classes will use electricity or the gaseous fuels for cooking while poorer countries will predominantly use solid fuels. These are the two extremes and many countries have a mixture of both with the ratio dependent on the level of development but globally it is estimated that more than 50% of the world's population use solid fuels and this figure is usually higher than 90% in rural areas (Bonjour, Adair-Rohani, Wolf, et al., 2013).

Solid fuels are used in less developed areas because of the relative ease with which they can be obtained, stored and burned. These fuels however tend to have a greater impact on the environment as they produce more particulates and carbon dioxide when burned, this impact is made greater due to the general low efficiencies of the stoves used. These higher levels of combustion products impact the environment on a whole but a more immediate danger is to the occupants of the households where they are used as they are known to induce higher rates of respiratory related illnesses and death. Furthermore when wood or wood derived charcoal is used as the solid fuel it generally results in widespread deforestation and the accompanying environmental problems of global warming, landslides, soil erosion, etc. (Desai, Mehta & Smith, 2004).

Electricity can be an efficient means of generating the heat for cooking but depending on the primary energy source used, the cost and environmental impact can be prohibitive. In countries, like Jamaica, that rely heavily on imported fossil fuels for electricity production, this costs makes it far less economical than LPG for cooking and the environmental effects of burning the imported fossil fuels (heavy fuel oil) can also be more severe than those of LPG. LPG and other gaseous fuels are not without their problems however, even though they are considered cleaner burning fuels, they still generate high levels of greenhouse gases when burned. Also recently the ever increasing prices of fossil fuels are becoming the major deterrent to their use. This increasing cost is also starting to pose a major threat to the economies of the world's more developed nations and therefore research in alternative energy and corresponding real world implementations have increased dramatically.

Jamaica is classified as a middle income developing nation and data from a 2007 home energy survey (Petroleum Corporation of Jamaica, 2007) shows that the primary fuel used for everyday cooking is LPG with solid fuels being a distant but significant second, a summary of the results is shown in table 1. The report also noted that although charcoal is used by both rural and urban households for cooking, its use is mainly or special occasions and as part of the preparation of specific meals.

Table 1. Jamaica Household Energy Use Survey Results.

	% of Households			
	Normal Source of Energy For Household Activities			
	Lighting	Cooking	Water Heating	Home Business
Electricity	90.8	1.3	70.8	85.7
Kerosene	7.9	0.4	0	5.4
LPG	0	86.0	4.6	0
Charcoal	0	5.2	1.5	7.1
Firewood	0	7.1	7.7	1.8
Solar Energy	0	0	15.4	0
Candle	1.3	0	0	0
Generator	0.1	0	0	0
Total	100	100	100	100

Although the high use of LPG for cooking indicates a relative high standard of living the continuing increase in prices for this fuel is certain to make it less accessible in the near future with an accompanying rise in the use of firewood and charcoal, leading to a higher rate of deforestation. Whereas most households are not looking to firewood or charcoal at the moment, the use of LPG adds to the ever increasing financial burden faced by the majority of the population.

LPG and liquid fuels such as kerosene and alcohols are considered as better alternatives to solid fuels for cooking and their use in efficient, modern stoves is generally seen as an indicator of a better standard of living. However they have limitations in terms of their environmental impact and continually increasing costs. To solve these problems in low income areas various solar thermal stoves have been proposed, designed and developed. There are many forms developed all over the world and the general idea is given by (Singh, Lippong, Ezriq & Narayana, 2012) and also (Kaasjager & Moeys, 2012). This technology however requires direct sunlight and suffers from sunlight's intermittent nature that plagues solar energy in general.

Advances in electric stove technology in the form of higher efficiency induction stoves may make it economically viable for a standalone solar photovoltaic (PV) system to supply a household's cooking needs. This technology offers clean, safe and efficient cooking but is however still under development and not in widespread use and any near future adaptation will most likely be by higher socioeconomic groups because of the current and expected cost of this technology.

An efficient, clean and low cost alternative fuel for cooking may be hydrogen. Hydrogen has been proposed as the major energy carrier for the future and the building block of the so called hydrogen economy. The major focus for the use of hydrogen is in transportation as a fuel for cars and buses or for the production of electrical energy from high efficiency fuel cells as shown by (Bilal, Benyoucef, Miloud & Ahmed 2012), (Mubenga & Stuart 2011), (Santoso, Setiaji & Susilo 2011) and (Xiao, Cheng, Lee, et al 2011), not much attention has been paid to the direct use of hydrogen for cooking. Hydrogen for cooking can be a shorter term goal and act as an intermediate step to full implementation of the hydrogen economy.

This paper explores the initial steps necessary to use hydrogen as the fuel of choice for domestic cooking in countries with very limited or no fossil fuel reserves but adequate renewable energy resources like Jamaica. Section 2 gives a general overview of the system and outlines the major technological hurdles that must be overcome for successful implementation of such a system on a large scale. Section 3 summarizes the work done so far on the project and the general direction of the system development, section 4 presents the conclusion and outlines further worked to be carried out.

System Overview

A high-level overview of the proposed system is shown in figure 1. below. This figure shows the main areas that have to be developed before this technology can be fully implemented.

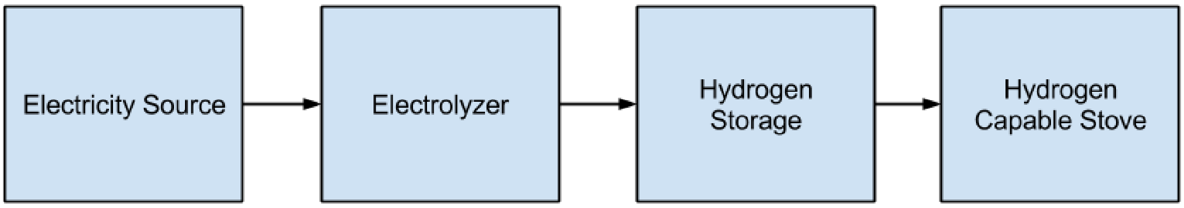

Figure 1. High-Level System Overview.

These technologies have to have some favorable characteristics for the generated hydrogen to be used as an economic fuel for domestic cooking, the following characteristics are highlighted:

1. The electricity source needs to be cheap and abundant.
2. The hydrogen storage medium needs to be cost effective.
3. The hydrogen stove needs to be safe, low cost and readily available in addition to having:
    a. A low cost and non-toxic method for easy leak detection.
    b. A low cost and non-toxic method to indicate when the stove is lit.

The development of these required technologies poses a significant challenge to the use of hydrogen for cooking but if this can be achieved then the potential benefits to the cost and standard of living in Jamaica and other developing countries, and environment at large, will be significant. Each of the above areas will now be explored and the current state of the art and proposed future direction will be illustrated.

Electrical Energy Source

The electricity used to produce the hydrogen cannot be produced from fossil fuels as this would negate one of the main benefits of using hydrogen, the elimination of harmful emissions. Therefore renewable energy sources are widely believed to hold the potential to satisfy this criterion, they are abundant and the energy source itself, in most cases, is free and current technology continues to enable the cost effective capture and use of these energy sources.

The major renewable energy technologies used throughout the world are solar, wind, hydro, and biomass. The generation of hydrogen from these sources continues to see intensive research and is generally geared towards generating hydrogen for fuel cell use in automobiles or for grid energy storage. Examples of this work are shown by (Bilal, Benyoucef, Miloud & Ahmed 2012) and (Bapu, Karthikeyan & Reddy 2010).

Renewable biomass in the form of sugar cane bagasse has also been used in Jamaica as a source of fuel for electricity generation in sugar plants but the boilers are old and were originally designed to dispose of the bagasse, process steam and electricity were byproducts. The quantities of electricity produced are considered too small to be able to sustain the required hydrogen production as there are times when the sugar plants have to purchase electricity or use diesel generators to supply their electricity needs. This can also be compounded by the seasonal nature of sugar cane bagasse (Detlef Loy, Manlio F. Coviello 2005).

Of these sources solar, in the form of photovoltaic systems, is considered to have the most potential for widespread adoption because of the ease in which it can be incorporated into modern housing designs. The cost of solar photovoltaic systems continues to decrease and this along with the reasonable availability of the solar resource in most parts of the world and the abundance in Jamaica and other developing countries in the Caribbean, Central America and Africa are the main reasons why photovoltaic solar energy was chosen as the best option for the primary energy source for the generation of hydrogen.

The hydrogen is produced from the electricity generated by the photovoltaic system through the use of a Polymer Electrolyte Membrane (PEM) electrolyzer. This type of electrolyzer is not the cheapest but its high theoretical conversion efficiency, ability to generate hydrogen at relatively high pressures, ability to work well with intermittent sources and its current rate of development (Santoso, Setiaji & Susilo 2011) makes it suitable for the initial phases of this work. The resulting photovoltaic system and electrolyzer setup is shown in figure 2. below.

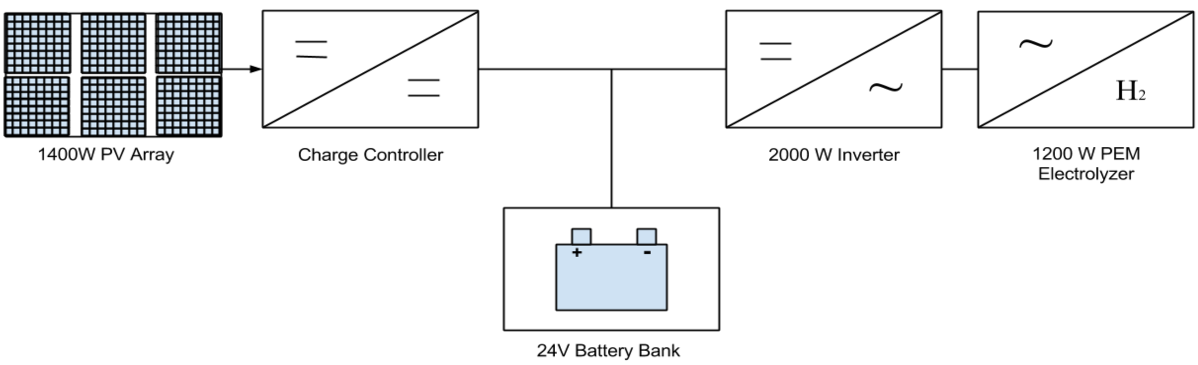

Figure 2.2. Photovoltaic System Schematic.

The work presented in this paper does not intend to develop any aspects of photovoltaic system or PEM electrolyzer technology but intends to use the current state of the art to assess the overall feasibility of using them to produce hydrogen for domestic cooking purposes.

Cost Effective Hydrogen Storage Medium

The storage of hydrogen has long been an essential technology to the successful commercial adoption of hydrogen as a primary energy carrier. The properties of hydrogen make it necessary for a large volume to be stored in order to get an acceptable usage time. In trying to achieve this, various technologies have been proposed and researched over the years, the main technologies are outlined by (Corbo, Migliardini & Veneri 2011) and (Riis et al. 2005) although additional references are provided below. The technologies are given as:

1. High pressure compression
2. Cryogenic storage as a liquid hydrogen
3. Solid storage in metal hydrides
4. Chemical storage in compounds

High Pressure Compression

This is now the most widely used method of storing hydrogen for distribution and involves using a compressor to compress the hydrogen gas to pressures up to 3000 psi in steel cylinders. Research in using compressed hydrogen for transportation is looking into using higher pressures in the range of 5000 psi to 10000 psi and this is made possible by the use of composite cylinders that are lighter than can operate at much higher pressures than their steel counterparts and are also presently commercially available (Mubenga & Stuart 2011), (Castañeda, M. et al. 2012).

Compressed hydrogen storage currently has properties that make it suitable for use as the technology for onsite storage for domestic cooking purposes. It is cost effective technology that is currently in use with the main technical challenge being increasing the energy density by increasing the storage pressure, the energy density however is not as great a concern for domestic cooking as it is for transportation as the option exists to use larger storage tanks at current pressures to get the required stored energy capacity

Cryogenic storage as a liquid

In this method of storage the hydrogen gas is liquefied and stored at cryogenic temperatures. This method has long been used as a rocket fuel in the aerospace industry because of its high energy density than compressed hydrogen.

The liquefaction of hydrogen requires more energy than to compress it although it has been argued that this cost can be offset by the cost of transportation of the finished product. Liquid hydrogen storage systems currently also suffer from evaporative losses when the stored for long times as will be required for onsite storage for domestic cooking purposes.

Solid storage in metal hydrides

This is currently the most promising solid storage and takes advantage of the small size of the hydrogen atom and the resulting ease in which it can embed itself in the crystalline structure of metals. The metal reacts with the hydrogen in an exothermic reaction to form the metal hydride, when heat is then applied to this metal hydride the hydrogen is then released (Marcotte & Domingue 2011).

Metal hydride storage technology seems to be a very good candidate for onsite storing of hydrogen for domestic cooking as the elimination of compression or liquefaction gives it the potential to be a very energy efficient. They are however still in the research and development as some technical hurdles, such as recharge times, still need to be overcome.

Chemical Storage in Compounds

The chemical storage of hydrogen uses compounds that are rich in hydrogen but have properties that are more favorable for economic transportation and storage than pure hydrogen gas itself. Conventional organic fuels can be considered as a form of hydrogen storage since they are compounds composed mainly of hydrogen and carbon, they however produce carbon dioxide when the carbon in them is burned and therefore cannot be considered a green alternative. These have been used in some applications to produce hydrogen via on site reformers.

Aqueous alkali metal borohydrides and rechargeable organic liquids are chemical compounds being investigated for storing hydrogen (Bonnetot & Laversenne 2006), (Sakamoto, Y. et al. 2010), but the general technology is still under development and they are not considered suitable for domestic cooking. Catalytic reforming of conventional fuels to give hydrogen has promise since we already have all the systems and infrastructure in place to safely transport and store, however for countries without significant amount of fossil fuel reserves this method would only give full benefit if some indigenous renewable source of fuel is developed.

Chosen Method

Of the methods available to store hydrogen, compression is chosen as the most suitable for domestic cooking as it is the most developed and the systems and infrastructure is already in place in most countries. The main disadvantage is its low volumetric energy density at presently available pressures. To overcome this, high pressure composite cylinders are being considered and will be investigated to determine their technical and economic feasibility. Another option being considered is to use storage cylinders that have a larger volume than those currently being used to store LPG for domestic cooking. The parameters and required specifications of these cylinders will be developed as part of this ongoing research and it is hoped that current commercially available cylinders will meet these requirements.

The hydrogen to be used can be produce centrally in a plant and delivered to customers in much the same way as LPG is handled now, however because of the use of solar energy as the primary energy source there is a real possibility that the gas needed can be produced locally at the residence where it will be used. This can dramatically lower the storage requirements but will have a higher capital cost due the acquisition of the required photovoltaic system. The sizing of the system under these two different scenarios, central plant and local production, and the merits of each will also have to be determined during the development of the system.

Hydrogen Capable Domestic Stove

A stove intended to burn hydrogen has to be able to accommodate the unique properties of the gas while being safe and reliable. Hydrogen gas atoms are very small and are therefore easily embedded into the crystalline structure of most metals, this can lead to the metal becoming brittle and prone to premature failure. The valves and other control mechanisms including gas regulators may also be affected or rendered useless by the small size of the hydrogen atom.Hydrogen is a colorless odorless gas and these properties pose significant risk to using it safely in the home. A solution has to be provided that will alert the user of leaks as soon as possible. This problem is also one that was faced by LPG systems and the solution has been to add distinct odor to the gas so that a leak can be easily detected. Common odorants are usually based on organo-sulphur compounds called mercaptans and these will serve as the first candidates for the odorization of the hydrogen gas. Questions to be answered in investigating their suitability include their long term stability when mixed with hydrogen and what is the best way to add these odorants to the hydrogen gas. The answering of these questions constitutes a part of further works to be carried out by this research.

Another problem that has to be solved by the hydrogen stove is that of alerting the user when a flame is lit. When hydrogen burns the emitted light is largely in the ultraviolet region and this makes the flames almost invisible to the naked eye. Therefore there is a risk that the unsuspecting user may come into contact with an exposed flame since he cannot see it, especially if he is accustomed to an LPG burning stove. This problem has not received much attention since the majority of research around hydrogen has been for use in internal combustion engines or fuel cells and flame visibility is not an option in these applications. Solutions to this problem includes adding a substance to the gas to enhance visibility, coating the burners so they emit visible light when the flame is lit or using electronic means to detect the flame and alert the user.

In order for the time to commercialization and general acceptance to be reduced it is essential to use current technology as much as possible, to this end a commercially available stove was modified to burn hydrogen. This is done to assess the long term suitability of currently available stoves to burn hydrogen without any degradation or other ill-effects and with only minor modifications.

Results

A commercially available stove was modified to run on hydrogen and has been run for four hours, continuously preparing meals for a special event, fed from a compressed hydrogen cylinder from which the hydrogen pressure is regulated with a conventional LPG regulator. An electronic circuit alerts the user when a flame is lit and the system included no method to quickly detect a leak. The stove was used by a chef with no engineering background and during and after use it demonstrated no apparent ill-effects, this is very encouraging and paves the way for a longer term assessment. The following points summarize the work done in the project so far:

1. Solar energy captured by a photovoltaic system combined with a polymer electrolyte membrane (PEM) electrolyzer has been chosen as the primary source of hydrogen gas. A demonstration system was constructed and successfully generates usable amounts of hydrogen. Further analyses needs to be done to determine the sizing and specifications for a central plant or domestic production system.

2. Compressed hydrogen has been chosen as the means to store the produced hydrogen gas. The demonstration system used no compressor and stores the hydrogen in steel cylinders at 200 psi. Further work needs to be done to determine whether it's best to use composite cylinders at high pressures or large volume cylinders at moderate pressures.
3. A commercially available stove has been modified to burn hydrogen and preliminary test results are very encouraging. The modifications include a system to alert the user of a lit flame but no method was implemented to allow easy detection of leaks. After a solution is developed further longer term field test will be carried out in real world conditions at a limited amount of select locations.

Conclusions and Further Works

This paper presents the initial steps in developing a system to enable the economic and safe use of hydrogen gas for domestic cooking. This work is primarily focused on Jamaica and other tropical countries with limited to no fossil fuel reserves but is expected to be applicable worldwide as a green and low cost alternative to present cooking technology. The work so far shows that currently available technology has the potential to solve many of the technical issues posed to such as system. These include photovoltaic systems, PEM electrolyzers, current gaseous fossil fuel stoves and methods of storing hydrogen. This work however is just scratching the surface and intensive further work need to be done to assess the long term viability of the yet unproven components such as the stove and the storage of the gas. Also further preliminary work has to be done to enable the user to easily determine when a flame is lit and also to detect hydrogen gas leaks in a conventional home.

Next steps will involve field deployment to about five homes to serve as real world test sites. This however must be preceded by adequate testing of the safety features such as storage, leak detection and flame visibility. This testing will establish usage profiles that will help determine system specifications for hydrogen storage capacity and PV system size.

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Renewable Energy Futures – a Delphi Study of the Opportunities and Obstacles in Distributed Renewable Energy Growth Up to 2025

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Introduction and background

Decentralised energy production and markets for renewable energy (RE) technologies are expanding. This is due to the greener policy goals within European Union and globally resulting from sustainability concerns. All EU Member States have agreed in the energy and climate package to increase energy efficiency by 20%, to raise the share of energy consumption from renewable sources to 20%, and to reduce CO_2 emissions by 20% by the year 2020 (EU Commission 2008 and 2014). In the national burden sharing the share of renewable energy was set as 38% for Finland. In addition, a national target to reduce GHG emissions by 80% below 1990 levels by 2050 was set in a Finnish Government's foresight report (Prime Minister's ... 2009).

Policies play a major role, as growth is supported by, e.g. EU policies for renewable energy and subsidy systems introduced in all EU member states. The allocation of support systems varies. For example, in Finland the feed-in-tariffs are allocated to large-scaled plants whereas in Germany small-scaled energy production is more extensively supported (Fulton & Capalino 2012, KPMG 2012, Koistinen et al. 2014). The German *Energiewende* is one example of a strong turnaround in long-range energy policy (BMU 2012a). As a result, consumer electricity prices have risen, but at the same time, the capacities of different renewable energy sources have increased considerably (Trendresearch 2011). This has meant new business opportunities and a need for new networks and concepts to emerge in local level (Wasserman et al. 2012).

While the traditional energy production is based on a centralized large-scale infrastructure, the emerging customer-side business concepts are based on a large number of small projects especially in Germany (Koistinen et al 2014). These small-scale projects, in which energy production occurs in the consumption section of the energy value chain, instead of energy utilities, are conducted through, for example, communal investment networks, co-operatives and farm clusters. According to Richter (2012), these customer-side business models are in an early stage of development. Small-scale energy production in households, farms or small enterprises has received relatively little attention to date in the energy transition. Distributed systems can, however, help in achieving the official targets, as well as offer economic opportunities for small-scale energy producers and the producers, retailers, and installers of energy devices. Although Finland has an important share of renewables in its energy mix, renewable energy production is mainly centralized.

In this paper the opportunities and obstacles of the distributed, small-scale energy sector in Finland are assessed. This is done through a Delphi study in which preferred and probable future views of an expert panel are constructed into scenarios. The constructed scenarios represent alternative future paths of small-scale energy until 2025.

Material and methods

The material for this study consists of a two-rounded Delphi process that was conducted in Finland in August 2013–February 2014. The Delphi method is widely used within futures research. Its users aim to explore alternative future images, possibilities, their probabilities of occurrence, and their desirability by tapping the expertise of respondents. The Delphi method consists of experts' judgments by means of successive iterations of a questionnaire, to show convergence of opinions or to identify dissent or non-convergence (Linstone and Turoff 1975, Sackman 1975, Kuusi 1999, Rowe and Wright 2001). There are three traditional principles that can be considered as irreducible elements of the technique, namely anonymity in answers, iteration and controlled feedback between organised enquiry rounds (Rowe and Wright 1999, 2001). Rowe and Wright (1999) also mention statistical aggregation of responses into a group response as a central characteristic, but in dissensus-based Delphi applications (e.g. Tapio 2003, Steinert 2009) such as the one used here, several group responses rather than a consensus seeking single response are sought for.

The Delphi panel

The Delphi panel experts were selected to represent the value chain of renewable, distributed energy production in Finland. The purpose was to cover the relevant viewpoints to be found within the field, and this was thought to be achieved best with a wide range of experts. Some panellists could be considered stakeholders rather than experts in a strict academic sense (see also Varho and Huutoniemi 2014).

The respondents were chosen with the help of an expertise matrix. Although some characterisation of respondents was done by the research team in order to find appropriate panellists, the respondents were also asked to estimate their own expertise. They named the renewable energy forms and the roles in the value chain they were most familiar with. The expertise of the panel that completed the second-round questionnaire is itemised in Table 1. In many cases there was more than one respondent who filled the two dimensions of a cell. For example, there were several panellists whose expertise covered energy production and biogas. Although the cover is not perfect, each energy source and each field of expertise got some coverage.

Table 1. Second round expertise matrix, based on experts' own estimate.

	Energy source / Fuel									Panellists in total
Field of action / Area of expertise	Solar power	Solar heat	Bio/ biogas	Bio/ ethanol	Bio/ micro-CHP	Wind power	Heat pumps (ground, water, air)	Hybrid systems	Other	
Fuel supplier					x					1
Equipment production and provision	x	x	x		x			x	x	6
Energy production	x	x	x	x	x	x	x	x	x	6
Energy transfer/distribution	x	x	x			x	x	x	x	3
Research & development	x	x	x	x	x	x	x	x	x	12
Consumer	x	x	x	x	x	x	x	x	x	6
Other			x							2
Panellists in total	9	10	7	2	3	4	6	10	4	

The bottom row of Table 1 indicates the number of panellists that named the energy source in question as their technological background. The right-hand column displays the number of panellists having indicated the field in question as their area of expertise. Solar power and heat as well as hybrid systems are somewhat more represented in the panel than other individual technologies. However, by combining together all bio-based technologies, also bioenergy is strongly represented.

Eight panellists work in large organisations of over 250 employees. Four panellists work in middle-sized organisations and six in small organisations of fewer than 50 employees. Their work relates to distributed, renewable and small scale energy production at least monthly, most commonly daily. Most panellists have a technical education, but some have an economic, social scientific or natural scientific background. Four panellists have doctorates, twelve have academic degrees or higher vocational diplomas. Two have a vocational or college education.

The first round of the Delphi study data was gathered mainly through semi-structured interviews. A first round questionnaire was developed and pre-tested by the research group and two additional experts in the distributed energy field. Based on the pre-testing, a few questions were eliminated to avoid a too laborious questionnaire. The structure of the first round questionnaire allowed experts to express new questions or statements of their own. The aim was to assure that the principle of an iterative specification of answers could take place.

During the first round, 17 persons answered a questionnaire in face-to-face interviews. Further 9 experts responded to a similar questionnaire online. The second-round questionnaire was organised as an online questionnaire. A feedback report was sent together with the questionnaire to the panellists who had responded in the first round. 18 responses were received from the second round.

The questionnaires

In the first round altogether 50 driving forces were addressed concerning the renewable, distributed energy production in Finland. These were asked under four themes, namely (1) RE technology solutions, (2) RE market functionality, (3) RE business concepts, and (4) energy policy and support to RE. The respondents gave their preferred and probable future view and an importance evaluation of each individual driving force using a five-step Likert scale. There was also a set of questions about business opportunities, and some open ended questions.

In the second round, a selection of the first round results were returned to the expert panel to get feed-back and re-evaluation of the results. These selected questions were chosen based on the rated importance, differences in preferred and probable future images, and deviation between the answers of the panellists. The panellists were shown their own response from the first round as well as the distribution of answers by the whole panel. The answers were asked for on the Likert-scale of –2 to 2 (–2 refers to substantial decrease from present level, 0 refers to no changes to present level and 2 refers to substantial increase from present level).

In addition, a new questionnaire part was prepared, based on the analysis of the first round questionnaire and interviews. The respondent gave his/her future view on the development of various business concepts and on the increase of capacities of different RE technologies (i.e. installations of different energy sources). In these two sections an index was used. The present level (end of the year 2013) was defined as 1, and the panellist could give any number for the 2025 level.

In a final section, the panellists were asked to mark up to five most important obstacles in Finland for the growth of distributed RE capacity, for the growth of new business activity related to distributed RE, and for the export activity related to distributed RE. They were given a list of 16 obstacles to choose from. The answers from this final section were not used directly in the scenario construction and are reported separately in the end of the paper.

Cluster analysis

In this study, the data was gathered so that the preferred and probable future development were asked for separately but analysed simultaneously. These formed the basis for scenario construction. The data analysis was mainly performed with cluster analysis. The analysis was based purely on the second round answers (n=18, giving 36 visions of the future as each respondent provided both a probable and a preferable vision). All other questions but the obstacles were used in the clustering. The obstacles were excluded because they did not follow the same preferred/probable format as the other questions, so there were only 18 responses.

The statistical runs were done using IBM SPSS Statistics 21 software. Classification is often a useful way to analyse data. Cluster analysis is a collection of statistical methods which identifies groups of samples behaving similarly or showing similar characteristics. The simplest mechanism is to partition the samples using measurements which capture similarity or distance between samples (Romesburg, 1984).

Within the method, hierarchical cluster analysis is the major statistical method for finding relatively homogeneous clusters of cases based on measured characteristics. It starts with each case as a separate cluster, i.e. there are as many clusters as cases, and then combines the clusters sequentially, reducing the number of clusters at each step until only one cluster is left. The clustering method uses the dissimilarities or distances between objects when forming the clusters. The SPSS programme calculates 'distances' between data points in terms of the specified variables (Burns & Burns 2009). A hierarchical tree diagram, called a dendrogram on SPSS, shows the linkage points.

Cluster analysis has often been used to construct scenarios from Delphi data (see Tapio 2002, Rikkonen 2005, Rikkonen & Tapio 2009, Varho & Tapio 2013). Here cluster analysis was used because it allowed categorising similar future views of distributed energy system experts in clusters. To give equal weight to all variables, the values were standardised to a scale between 0...1 in each variable, as the scale had varied between the questions.

Results

Scenario construction

The dendrogram of clustered responses is given in Figure 1. We selected five clusters as the basis for the scenario construction. The aim was to find 4–7 clusters, because such a number has been considered suitable for scenario sets (see Varho & Tapio 2005). These five clusters represented sufficiently different viewpoints regarding the future development, so that an interpretation was possible to be found for the set. The average value (i.e. cluster mean) was calculated for each variable from the future images (both probable and preferable) that were included into each cluster. The scenario descriptions were constructed based largely on these values.

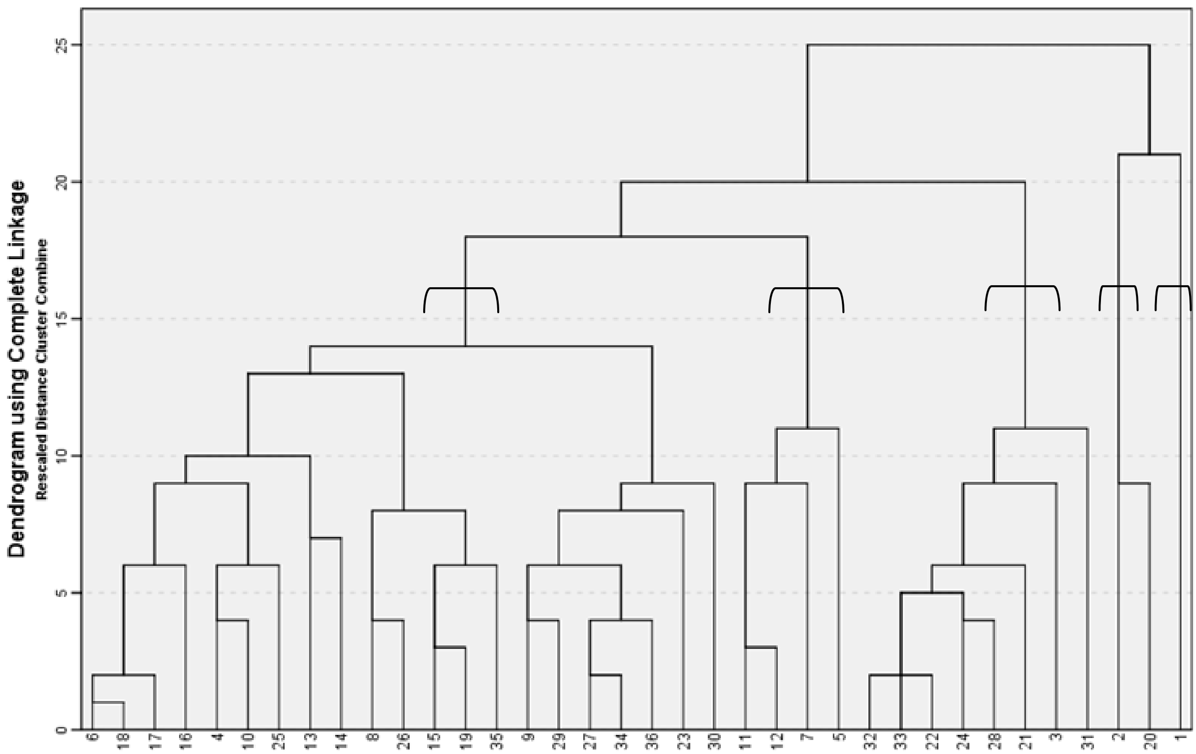


Figure 1. The dendrogram used in the scenario construction, depicting five clusters.

The order of scenarios described here is based on the overall renewable energy capacity growth, from smallest to largest. The RE capacities and the increase of various business concepts in each scenario are depicted in Figure 2. Concerning RE capacities, also the growth of hybrid solutions was asked in the questionnaire, and was included in the clustering. It was, however dropped from Figure 2 due to the ambiguity of the variable in answers.

Stagnation

As the name implies, in the scenario *Stagnation* very little change takes place, in any field. For example, there is almost no potential for off-grid solutions. Support policies to renewable energy remain rather similar to present day, although the focus shifts slightly towards removing bureaucratic obstacles and to R&D funding. Investment subsidies to small-scale producers actually decline. The roles of consumers and small-scale producers are rather traditional, and there is no significant growth in the business concept prevalence. A positive change is the growing number of component and equipment manufacturers as well as of business networks providing ready-to-use installation packages for small-scale producers. The *Stagnation* scenario describes a future where some companies begin to grow, some very minor growth takes place in all considered renewable energy forms, but no real transformation takes place in either political, business, or consumer level.

Business-as-usual

The *Business-as-usual* scenario presents a stable but calm growth track for RE capacities, accentuating PV, and to some extent micro-CHP and solar thermal energy production. Power generation is relatively more pronounced than in the *Stagnation* scenario. Also policy development is quite stable. Particularly administrative steering has eased bureaucracy related to various permission processes and grid connections. R&D funding has increased and national low-interest financing programmes have emerged. Investment subsidies have increased more than the long term subsidies. Different business concepts have arisen, but their popularity grows at a slow and even pace throughout the concepts.

The "German way"

The name of the *"German way"* scenario refers to the German *Energiewende* policy as well as to the significant growth of RE energy production and various types of business concepts. In this scenario, there are lots of off-grid solutions. Sales and marketing cooperation between small-scale producers and traditional energy companies, RE produced in small-scale co-operatives, and joint investments in procuring small-scale RE systems have become popular business concepts. There is strong policy, particularly in terms of long-term support such as feed-in tariffs and national low-interest financing programmes. There is also significant R&D financing. Planning is not forgotten, either, as construction permits and connections to the grid are easy to get, and local plans direct towards renewable energy solutions. As a result, the regional networks for ground heat pumps gain popularity faster than in the other scenarios. All renewable energy form capacities grow significantly, with an emphasis on biomass through micro-CHP solutions.

Solar business prosperity

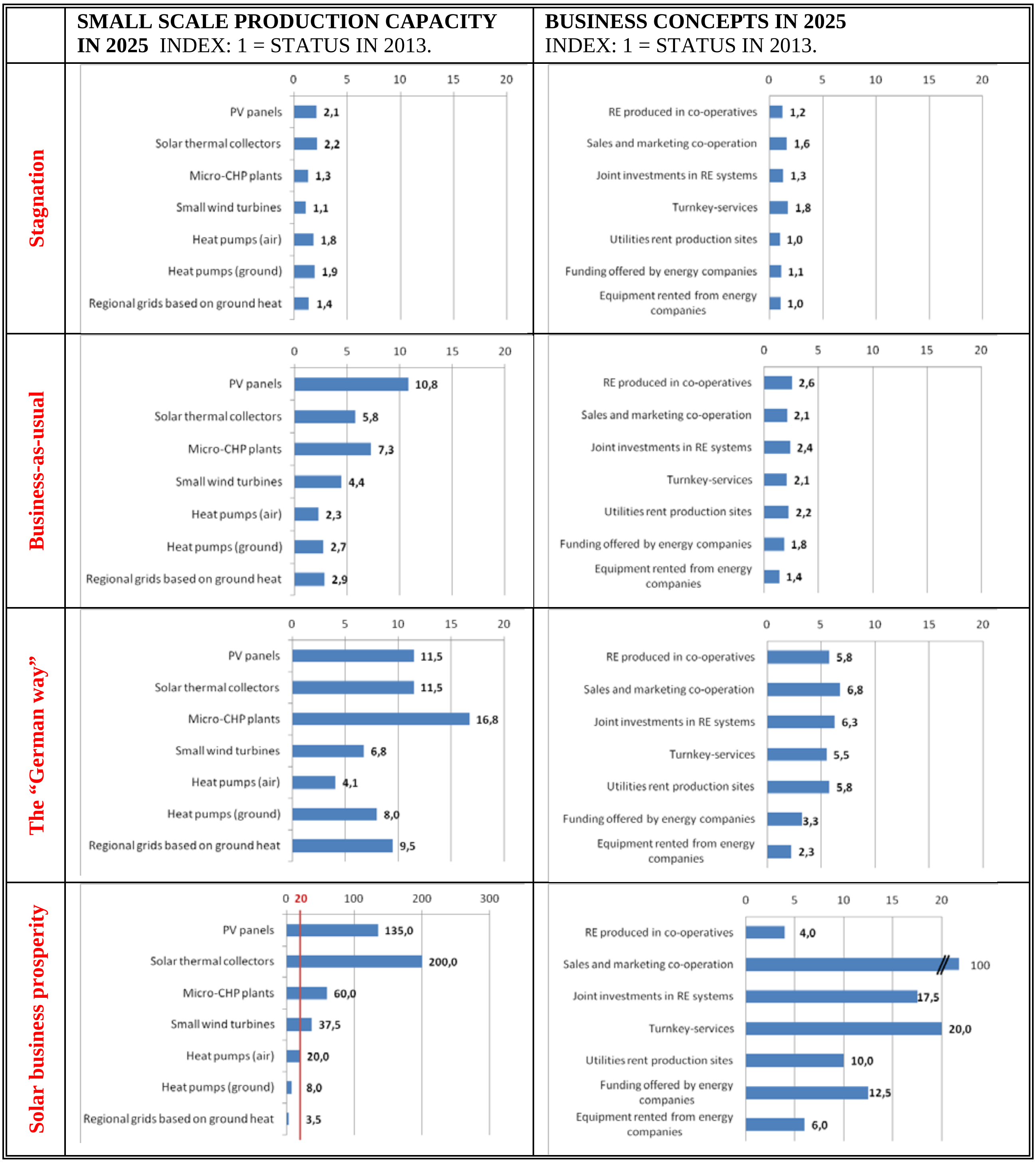
The *Solar business prosperity* scenario shows great growth in RE instalments, with the focus firmly on solar solutions. Unlike in any other scenario, here solar heat grows even faster than solar power. The growth has been achieved, in particular, by making the transition to renewable energy easy to the end customers. Choosing renewable energy from a small-scale producer has become easy and commonplace. For example, traditional energy companies co-operate with small-scale producers by selling and marketing their energy to end consumers. Also ready-to-use installation packages for small-scale producers have become widely available. Policy development is more modest, focusing on R&D financing and easement of construction and grid connection permits.

Electricity expansion at grass roots level

In the *Electricity expansion* scenario solar power and small-scale wind power generation has "exploded", and significant growth has also occurred in the installed micro-CHP capacity. Capacity growth has been relatively slow for heat production capacity such as heat pumps and solar collectors. As opposed to the *Solar business prosperity*, active involvement of citizens has played a significant role in the transformation. Co-operatives and joint investments in energy production equipment have become popular business concepts and forms of community involvement in distributed RE production. Long-term support mechanisms such as feed-in tariffs and national low-interest financing programmes have increased substantially. Permissions can be obtained easily for RE production systems. Differences in subsidy levels for different RE forms have decreased significantly from their current state.

Obstacles for the growth in distributed renewable energy

The panellists considered the underdevelopment of business concepts such as turnkey solutions the greatest obstacle for small-scale RE capacity growth (receiving 13 "votes"). Also the difficulty to find trustworthy information on RE systems (9), the insufficient availability of professional sales and installation services (8), the difficulty or lacking profitability of selling small amounts of electricity (8), and the price of production systems (7) were among the top five barriers for capacity growth.



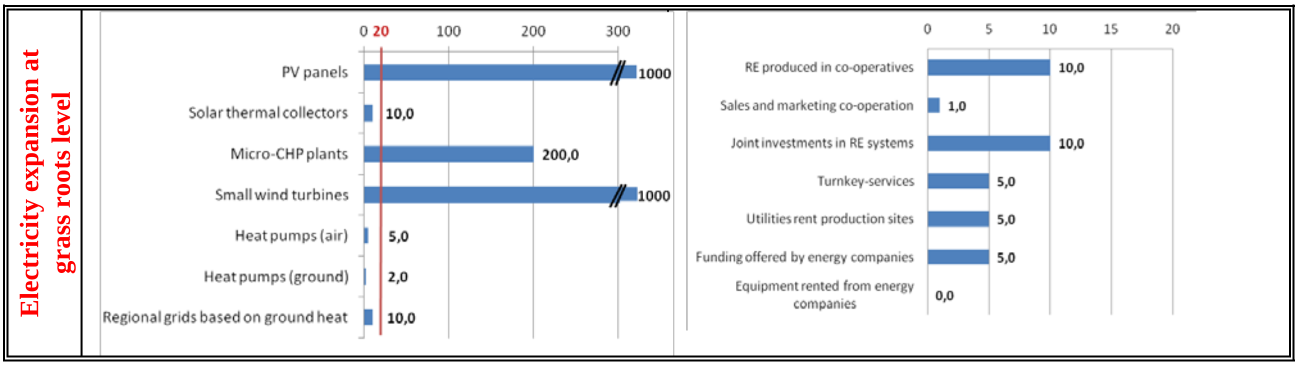


Figure 2. Scenario characteristics related to capacity growth and business concept increase.

None of these obstacles emerged in the top five obstacles for the business opportunities in RE in Finland. Instead, the greatest barriers were the difficulty to get financing for companies offering equipments or services (11 "votes"), lack of co-operation between companies (10), the unpredictability of RE policy (9), the lack of demand (as buyers have little interest in new energy solutions) (6) and the lack of R&D funding (6).

Discussion and conclusions

The five scenarios described here are fairly different from one another, but they reflect certain basic assumptions that seem to exist in Finland.

First, even the *Stagnation* scenario demonstrates *some* growth, and some scenarios are extremely optimistic. It seems that recent global growth in modern renewable energy are reflected in the RE capacity estimates. When the future views on different RE forms are compared, their starting levels must be kept in mind. Heat pumps have been fairly popular in Finland (Sulpu 2014), and their capacity is presumably much higher than that of solar panels or solar heat collectors. This is visible in the estimated rate of growth, as each energy form was given the index value 1 for the state at the end of 2013. *Solar business prosperity* demonstrates great faith in the future of solar applications in Finland, and all scenarios, apart from *Stagnation*, envision at least a ten-fold increase in only a decade for photovoltaics. The visions of strong growth are supported by recent development in other countries. For example, 21 000 MW of photovoltaic capacity was installed in the EU in 2011, which was almost half of all new power installations in the EU that year (EWEA 2012). Germany has been very active in this field, and the installed PV capacity grew from 75 MWp to 25 000 MWp in 2001–2011 (BMU 2012b).

Second, there is no scenario where significant growth in RE capacity would be combined with little governmental support. In *Solar business prosperity* the support is connected more to R&D and decrease of regulation and bureaucracy, but governmental involvement is still necessary to some extent. *Stagnation* scenario shows that quite slow growth is seen as a distinct possibility, strongly connected with lacking governmental support.

It is quite likely that subsidies to renewable energy will not significantly increase in Finland. This is in part due to the current economic situation but perhaps even more to the hostility of many existing political and energy sector actors towards new RE actors and policies (e.g. Salo 2014). How could RE be supported then? When the panel was asked about the greatest barriers to distributed RE capacity growth, the top three were not related to subsidies. Instead, insufficient services and business capacities were named. It seems that growth might be generated by addressing the business sector. Of course, some of the most needed changes for the developing business sector were thought to be improved RE policies.

Emphasising the business environment rather than subsidies also reflects the aversion some interviewees had for subsidies in the first place. Interfering with free competition and market mechanisms, in order to support renewable energy, has occasionally been opposed intensely in Finland (Varho 2006, 2007). R&D funding and national low-interest funding such as loans provided by the German KfW development bank (Koistinen et al. 2014, KfW 2014) could be more acceptable. Currently there is no Finnish funding program directed at RE on national level.

Third, an interesting topic that emerges from the scenario set is the role of citizens and consumers. When the panel was asked about obstacles for capacity growth, the most important ones reflected the underdeveloped business sector, such as lacking information and services. The two scenarios that demonstrate most growth (i.e. *Solar business prosperity* and *Electricity expansion*) have two very different solutions to this.

In *Solar business prosperity* the business sector has been renewed, and adequate services are available. Anyone investing in RE will find appropriate equipment and services, and permits and grid connections are easily arranged. In addition, small-scale production has been connected to ordinary consumers as traditional energy companies co-operate with small-scale producers, selling and marketing their energy. In *Electricity expansion*, on the other hand, the old businesses have to some extent been bypassed. The actors in the market are not so much producers and consumers but *prosumers*. Community-based solutions have become popular. Such development would benefit from local participation and from the distribution of the benefits of energy production locally, issues which have increasingly been mentioned as factors facilitating RE uptake (Rogers et al. 2008). Again, Germany is an interesting comparison, as private citizens owned 40% of RE capacity in 2010, often through co-operatives, and farmers another 11%. This has reflected both the lucrative RE policies and the German tradition of collective civic action (Buchan 2012).

For the future of distributed, small-scale renewable energy production in Finland, important questions thus arise: How will the RE business sector be able to form networks, co-operate and improve its business concepts? What will be role of citizens – do they remain as passive consumers or take an active role? How will the government face the challenge of legislation that slows down the expansion of new business concepts, grid-connections and installations? Depending on the answers, the RE future in Finland can follow very different paths.

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Combining Expert Future Views and Farm Level Modeling in the Evaluation of Three Mitigation Policy Measures – Improving the Base for Future Decisions

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This paper focuses on using both quantitative and qualitative approaches in generating research results for climate change mitigation policy measures within agriculture. This is done by integrating interactively farm level model simulations with future views of an expert panel. The Delphi method with an expert panel is utilised together with the modelling of alternative types of farms to evaluate the effects of different mitigation policy measures. Farm level simulations delivered projections to serve as benchmarks for the expert panel to evaluate and foresee the possible introduction of these measures. Three mitigation policy measures are simulated at the farm level out of 20 mitigation policy measures that are assessed by the expert panel. These measures are 1) the benefits (decreased emissions) and costs of requiring farms with organic soils to cultivate perennial grass on them 2) requiring livestock farms to change feeding practice and intensify diet for livestock in order to decrease emissions (increasing rape oil in feeding) and 3) storing feed grain without drying (avoiding mainly fossil fuel use). The benefits of combining farm level modelling and Delphi method materialise from a more accurate base for expert evaluation. Delphi questionnaires typically remain at a general level and lack important details. The model simulations give insights on the potential of the mitigation policy measures at the farm level, whereby the expert panel can compare and evaluate the different impacts of the policy measures.

Key words: Delphi method, farm model simulations, mitigation measures, climate policy

Introduction

In the literature, there are examples of combining qualitative and quantitative methodological approaches in Delphi studies. The qualitative approach refers to the analysis of qualitative material. The quantitative approach, in turn, refers to the gathering and analysis of quantitative, i.e. numeric, countable, research material (Armstrong 2001). Examples of combining economic modelling with the Delphi method are rare, as they are traditionally seen to lean fundamentally on different sources of knowledge source, statistical and judgemental information (Armstrong 2001). However, combining these methods to a mixed method study can provoke new ideas and increase the depth of the knowledge base needed in decision making (Creswell 2008; Tapio et al. 2011).

In this paper, both quantitative and qualitative methods are used to analyse the impacts of different climate change mitigation policy measures on agriculture. The concept mitigation policy measure refers to measures that have been identified within the 'Future alternatives and impacts of changing climate and energy policy within agricultural operational environment (ILVAMAP)' research project. The Finnish Government has published a Climate and Energy Strategy in which the agricultural sector is given a 13% reduction target for greenhouse-gas emissions in 2005–2020. The strategy does not define which mitigation measures should be used to reach the target, but forthcoming mitigation policies in Finland pose important questions on the formulation of future policies for Finnish agriculture (TEM 2013.). For example, important issues to be clarified are emissions from land use changes, especially organic soils, production animals, manure, and energy use on farms. Emissions from agriculture are about 9% of the total greenhouse gas emissions from Finland (Statistics Finland 2014a). It has to be noted also that CO_2 emissions from soil are included in LULUCF-sector (Land Use, Land-Use Change and Forestry). Therefore, in the IPCC sector reporting they cannot be counted for the benefit of agricultural sector.

In this study, farm level modelling and the Delphi method are used in combination. Farm level modelling estimates the effects of the chosen three policy mitigation measures to the GHG emissions and the expert panel evaluates the same measures in terms of 1) farm level acceptability and 2) effectiveness in reducing emissions. The farm level acceptability is an important dimension because the studied measures have an effect on costs and require changes in production. Therefore, there is a trade-off between reduced green house gas emissions and increased costs for farms. Also, the effectiveness to reduce emissions from agriculture varies considerably between the studied mitigation policy measures.

The main methodological purpose of this paper is to experiment the use of farm level modelling to provide insights for the Delphi questionnaire in order to gauge the impact of a specific mitigation policy measure at the farm level. This will provide the expert panel an opportunity to evaluate the impact of a specific mitigation policy measure by assessing the farm level acceptability and the effectiveness of the studied measures to reduce greenhouse gas emissions from agriculture in Finland.

The research questions are defined as follows:

- What are the benefits of combining farm level modelling and Delphi method?
- How can these methods be used in parallel in evaluating climate change mitigation policy measures in agriculture?
- How do mitigation policy measures position themselves if further information is given to panellists?
- What is the final outcome after two rounds of questionnaires? Are there differences in the way the experts evaluate general and specific mitigation policy measures between rounds?

Material and Methods

Farm level modelling

In this study, alternative farm types are modelled to evaluate the effects of different mitigation policy measures. Farm level research calls for more specific farm level data in order to represent and formulate the research question of this study.

1) Farm level modelling on increasing rapeseed oil in livestock feeding

The farm level simulation is based on a large dairy farm, which has 160 dairy cows with average yield of 9104 kg of energy corrected milk (ECM). The average weight of cows is fixed to 674 kg. The size of the farm, milk yield and weight of the cows are much higher than the current average. However, these values represent how a large dairy farm might look like in the future by following current developments. The model includes a simplified feeding calculation, which is based on feeding standards of dairy cows, determined by MTT (2014). The requirements are not official, but they are based on large amount of experimental data. The requirements account for animal daily consumption of energy and need of protein for maintenance, milk production, live weight change and pregnancy. In the baseline, the diet consists of grass silage (D-value of 656 g/kg dm), feed barley and oats mixture of 50–50%, and rape seed meal. In the scenario, crushed rapeseed is added (including the oil) to the diet so that crude fat concentration of the daily diet achieves the level of 70 g/kg dm. The crushed rapeseed partially replaces cereals and rapeseed meal in the normal diet.

2) Farm level modelling on requiring farms with organic soils to cultivate perennial grass

The farm level simulation assumed that cattle farms in Finland would be able to allocate their own feed grain production from organic soils to mineral soils or replace the lack of feed grains from the market. The data is retrieved from the annual cultivated areas recorded at the Finnish register for field parcel from the year 2009 according to production lines. The soil type of each field parcel according to WRB-classification (The World Reference Base for Soil Resources, FAO 2006) is identified with the Finnish Soil Database (Lilja et al. 2009). The soil type is divided into three main types: mineral soils, mould soils and organic soils. It is revealed that cattle farms cultivated 33 000 hectares of grain crops on organic soils. Thus, the effect from allocating these field parcels with organic soils to perennial grass production can be estimated.

3) Farm level modelling on storing feed grains without drying

The farm level simulation estimated the energy saving potential by storing feed grains without drying. It is possible to preserve feed grains without drying, for example with air-tight storing. The problem is that there are very limited markets for "wet stored" grains, hence it is mostly an on-farm solution. In terms of feeding values, it makes no difference if the grain is preserved wet or dry. In 2012, feed grains were cultivated on 786 000 hectares. The yield of feed grains was 2.7 billion kg. From this, 1.6 billion kg was used direct at farms as fodder (Tike 2014). In northern latitudes, grain is usually harvested when the grain moisture is 23% on average; this is because of short growing season. The grain must be dried to 14% moisture for preservation. The drying process requires a lot of energy, usually fuel oil. The consumption of fuel oil on feed grain drying cause 57 398 tons of CO_2 emissions annually (Kässi, Lötjönen & Niskanen 2014).

Delphi method

Delphi as a research method has been widely used in futures studies. The users of the Delphi technique aim to predict and/or explore alternative future images, possibilities, their probabilities of occurrence, and their desirability by tapping the expertise of respondents (Linstone and Turoff 1975). In the method, information is obtained from experts through questionnaires and interviews, after which the information is revised with one or more additional rounds of information gathering. Prior to a new round of answers, the experts are informed of the results of the previous round. This allows individual experts to position themselves in relation to the opinions of the group of experts. The principle of several rounds in Delphi method enhances learning to take place during the process. The participants get the results from previous round and can familiarize themselves with the argumentation that other participants have presented. Therefore, a participant can receive a confirmation for his/her future view or change his/her view on future development based on the arguments that the others have brought to the table.

In this study a two round Delphi was used. The selection of the panel is a critical phase in using expert judgement methods like the Delphi technique (Kuusi 1999). We proceeded by preparing the criteria and classification for choosing experts according to the research goals (substance of climate change, renewable energy and agriculture). The needed expertise and actors in agricultural field were determined in an expertise matrix. In that the decisive dimensions were 1) expertise and educational background (agriculture, climate change, renewable energy, economics, social science in general, technological and natural science) and 2) actors in agricultural field (research and education, agricultural producers, administration, NGO's, agricultural extension, interest groups, food industry and trade). Also at this phase, the preliminary panellists were listed by the research group. The Delphi managers contacted the chosen experts by e-mail and phone call to organise an interview meeting. The empirical data were gathered between summer 2013 and spring 2014. A questionnaire was send out beforehand and was immediately followed by interviews. The second round was conducted with an online questionnaire. The first round questionnaire was sent to 36 experts of whom 28 returned it.

In all, the expert panel evaluated the mitigation policy measures by 1) probability of the use, 2) desirability, 3) societal acceptability, 4) farm level acceptability 5) the broadness of implementation, 6) the effectiveness to reduce emissions and 7) the overall importance. The farm level acceptability is an important dimension because many of the studied measures also increase costs and require changes in production. Therefore there is a trade-off between reduced green house gas emissions and increased costs for farms. Also the effectiveness to reduce emissions from agriculture varies considerably between the studied measures.

The combination of farm level modelling and Delphi method

The Delphi method is used in parallel with farm level modelling to evaluate above mentioned policy measures according to the results from the farm level simulations. The specific simulation results are presented to the panellists together with the general measures. The difference between specific measure and general measure is that in specific measure the simulation results are presented whereas in general measure the question is posed without any background information or simulation results.

The research process proceeded as below:

1. farm level simulations (first simulation results on specific measure together with evaluating the general measure)
2. first round Delphi questionnaire (expert evaluation of a specific and general measure, specified dimensions)
3. refined farm level simulation results (more defined results, overall emission reduction in all reporting sector of green house gas emissions from agriculture)
4. second round Delphi questionnaire (re-evaluation of the measures, selected dimensions)
5. Conclusions

There were altogether 20 individual mitigation policy measures in the Delphi questionnaire. Three measures in the questionnaire included results from the farm level simulations, and therefore providing more information on the effects of a specific measure at the farm level. In this paper, three general mitigation policy measures are further investigated with specific mitigation policy measures. These measures were 1) the benefits (decreased emissions) and costs of requiring farms with organic soils to cultivate perennial grass on them (refer to Appendix A), 2) requiring livestock farms to change feeding practice and intensify diet for livestock in order to decrease emissions (increasing rape oil in feeding), and 3) storing feed grain without drying (avoiding mainly fossil fuel use). These measures are evaluated in parallel with the general mitigation policy measures that have no background information on the potential to reduce the greenhouse gases.

Results

The farm level simulation results in the first round evaluation included:

1) Requiring livestock farms to change feeding practice and intensify diet for livestock in order to decrease emissions (increasing rape oil in feeding)

Livestock digestions, mainly ruminants, caused 27% of greenhouse gas emissions of the Finnish agricultural sector in year 2011 as observed by carbon dioxide equivalent (Statistics Finland 2014b). Animal science nutrition research has focused on finding methods to reduce methane emissions. Cattle lose 6% of their ingested energy as methane. This causes inefficiency to the animal feeding, because part of the valuable energy is lost. The other concern is related to the role of methane in global warming (Johnson and Johnson 1995). It has been discovered, that increased dietary fat concentration reduces methane (CH_4) production by enteric fermentation of ruminants (e.g. Ramin & Huhtanen 2013). Simulations made with additional half a kilo of rapeseed oil gave a result where, methane production was reduced by 8%. The dietary fat content should not exceed 70 g^{-1} kg dm, higher fat content is found to affect milk yield decreasingly. Concerning other features, rapeseed fits well into dairy cows diet. Some benefits are also achieved in the quality of milk, for example the fatty acid composition changes towards healthier direction for human consumption. Rapeseed is also the most common oilseed crop which is cultivated in Finland. If fat addition would be carried out by adding oil including rapeseed to the diet and rough feeds remain constant, the cost of the concentrate feeding would increase by 15% as observed by the price average of years 2009–2012. Thus, in the farm of 160 cows, reduction of one carbon dioxide equivalent ton would cost €43.

2) The benefits (decreased emissions) and costs of requiring farms with organic soils to cultivate perennial grass on them

Perennial grasses reduce the GHG-emissions of the organic soils. According the WRB-classification, there were approximately 330 000 hectares of organic soils under cultivation in Finland in year 2009, of which 44% were cultivated by perennial grass and 56% by grain crops. Cattle farms had 114 000 hectares organic soils and 33 000 hectares of it was cultivated by grain crops. If the cattle farms would cultivate perennial grass on that 33 000 hectare, it would reduce nitrous oxide (N2O) emissions by 123 783 carbon dioxide equivalent tons per year. The reduction would be 2.1% of the total agricultural emissions of 5.7 million tons of carbon dioxide equivalents in 2012. At the same time the amount of the plain carbon dioxide emissions would be reduced by 193 600 tons per year. However, greenhouse gas emissions from agricultural land use are calculated in the land use sector. Land use, land-use change and forestry (LULUCF) sector is not under the scope of the emissions trading scheme or under any reduction targets for greenhouse gas emissions. Therefore, the emission reduction from this mitigation measure is not calculated as an outcome for the agriculture sector, and hence cannot be used as a reduction in the total emissions for agriculture. Decreasing emissions measured from cultivating perennial grasses on organic soils would increase the carbon sink of the LULUCF sector by 0.75%. Possible costs of the implementation of this measure would originate for example from the need of supplementary sow and increased plant protection costs caused by renewal of perennial grasses without grain in the crop rotation. Cattle farms need to replace the yield of the reduced grain cultivation area with bought grain or, when possible, by concentrating the cultivation of the grain crops to the mineral soils of the farm. In this case, the cost would originate from increased transaction e.g. logistic.

3) Storing feed grain without drying (avoiding mainly fossil fuel use).

In northern latitudes, grain is usually harvested when the grain moisture is 23% on average. The grain must be dried to 14% moisture for preservation. When this is done for 1000 kilograms of grain, 88.6 kilograms of water has been taken out. Drying one ton of grain consumes about 12 kilograms of fuel oil. In the year 2012 feed grains were cultivated on 786 000 hectares. The yield of feed grains was 2.7 billion kilograms (Tike 2014). From this, 1.6 billion kilograms was used direct at farms as fodder (Tike 2014). Feed grain is also possible to preserve without drying, for example with air-tight storing. The potential of reducing fuel oil use for grain drying is 21.2 billion liters, if the feed used for cattle (568.3 billion kg.) and pigs (938.7 billion kg.) in year 2012 would be preserved without drying. Thus, the emission reduction would be 28,650 tons of carbon dioxide equivalents per year. However, this reduction in emissions would be considered as an outcome of the energy sector and not as a reduction in emissions from the agriculture sector. This mitigation measure to store feed-grains without drying would only reduce 0.06% of the total greenhouse gas emissions of 47.8 million tons of carbon dioxide equivalents in 2012 from the energy sector in Finland.

Basic results of the three mitigation policy measures in Delphi process (first round).

In the questionnaire there were two counterpart questions concerning the measures 1) increasing rape oil in feeding and 2) requiring farms with organic soils to cultivate perennial grass on them. These are described above. The counterpart questions without background information were more general, namely 1) Changes in feeding and 2) Perennial grass cultivation in the organic soil fields. The third measure "storing feed grain without drying" did not have a counterpart question. Therefore the results are presented as such.

General versus specific mitigation policy measure: Changes in feeding versus increasing rape oil in feeding

The overall importance was as big in both measures: general and specific, but there was bigger consensus among the general measure (Figure 1.). Desirability of changes in feeding was much bigger than in its counterpart question i.e. increasing rape oil in feeding. More information reduced the desirability. This can be explained by the deeper understanding of the relations between the use of the measure and outcomes. It is noteworthy some of the respondents saw the changes in feeding involve also other animals than cattle. Respondents answered that adding fat in the dairy cows feed is unphysiological for the species behavior and therefore it is an undesirable measure. The specific measures' probability of the use got almost the same points than desirability, but the points of the general measure differ more. Respondents estimated larger need for change in feeding systems in the general measure, as they considered it to be related to all livestock in various ways, not just adding fat in to the feed.

Farm level acceptability was the same in both measures, though the standard deviation was 33% bigger in the specific measure (versus general measure). This can be explained by the costs of the added rape seed oil in the feed and the increased need for rape cultivation. This is because crop yields vary a lot between years. Changes in feeding in general were seen more acceptable in societal dimension than the specific measure. Reasons for this can be found from the fact that fat does not belong to the diet of ruminants and thereby some aware citizens would not accept it. The broadness of implementation was seen higher for the general measure because respondents estimated more alternatives in the implementation. They also saw that costs must be optimized more in the future and changes in feeding could be one way to do so. It is noteworthy that some of the respondents saw the changes in feeding involve implements overall in the feeding and feeding systems not just ways how to reduce emissions. The specific measure was considered to be more effective to reduce emissions, although some respondents were arguing that the cultivation of rape come up with higher mitigation than grain crops cultivation. The additional information, with calculations and numbers, made the measure feel more effective although it was very costly.

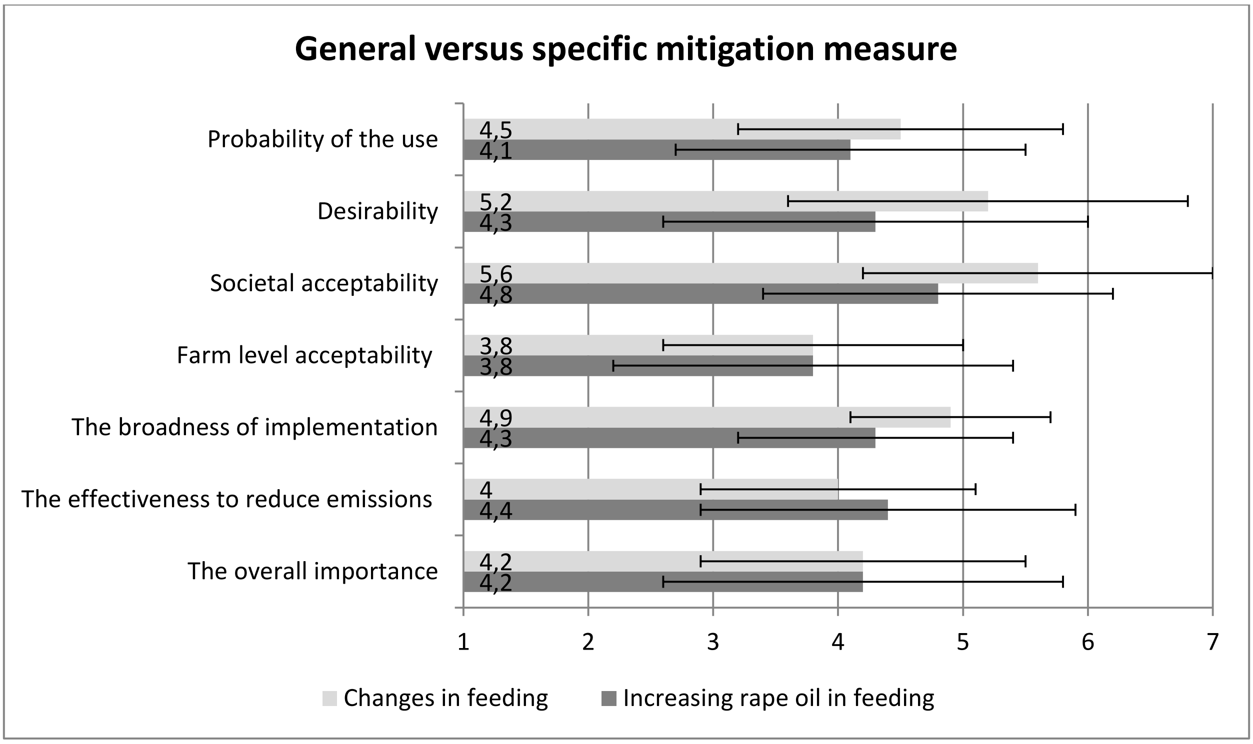

Figure 1. General versus specific mitigation policy measure; Changes in feeding versus increasing rape oil in feeding

General versus specific mitigation policy measure: Perennial grass cultivation in the organic soil fields in all farms versus requiring cattle farms with organic soils to cultivate perennial grass on them

In this question the general measure concerned all farms that possess organic soil field, whereas the spesific measure concerned only cattle farms. The overall importance was almost as big in both measures: general and specific, with the same range of consensus (Figure 2.). Desirability of perennial grass cultivation in the organic soil fields was a slightly bigger than in its counterpart question: requiring cattle farms with organic soils to cultivate perennial grass on them. More information did not impact on the desirability. This can be explained by the overall point of view for this kind of measure. Respondents did not saw appropriate to intervene entrepreneurs' way to manage their business. It is noteworthy that some of the respondents did not support any sanctions and therefore it is undesirable by nature. The probability of the use between these two measures differs more than their desirability, but not exceedingly. More information did not increase the probability of the use of the specific measure. This can be explained by the respondents' views that specific measure especially restricts cattle farms to run their business.

Farm level acceptability was little bigger in the general measure. Respondents considered that the farm may have other soil types inside the farm where they could transfer their production from the organic soils. Most of Finnish cattle farms are located in areas in where a lot of organic soils exist. Farms which have only organic soils in cultivation are more concerned by the special measure. How this kind of cattle farms should procure their concentrated feeds if they cannot cultivate them on their own fields. If they need to buy them, how expensive it could become and from whom they should buy them. Another concern was the implementation of the crop rotation on the organic soils. Perennial grass cultivation in the organic soil fields in general were seen more acceptable in societal dimension than the specific measure. This is because the idea of the special measure is to focus only on cattle farms, and therefore it is not fairly allocated. The broadness of implementation was seen as big in both measures. Respondents estimated this kind of measures to be forced to implement by EU in the future. The general measure was seen to be more effective to reduce emissions than the specific measure. This can be explained by the additional information: 56% of the organic soils are cultivated by grain crops and 18% of that area is possessed by the cattle farms. In the light of this additional information the respondents get the picture that it would be more effective to target this kind of measure to all organic soils or part of them rather than focus the measure only to the organic soils possessed by cattle farms

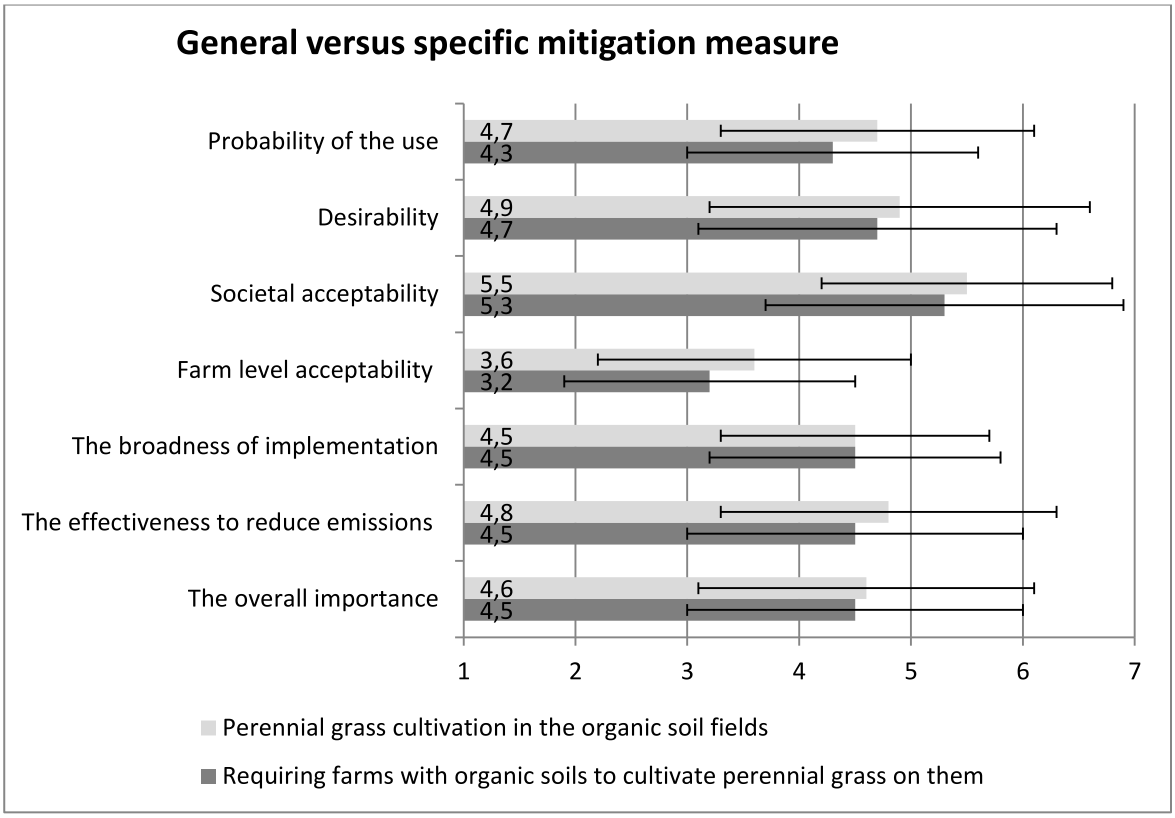

Figure 2. General versus specific mitigation policy measure: Perennial grass cultivation in the organic soil fields (all farms) versus requiring cattle farms with organic soils to cultivate perennial grass on them (only cattle farms)

The overall importance was considered most important among these specific questions and among the overall 20 measures it was rated sixth important (Figure 3). Also desirability of storing feed grain without drying was highest among specific questions. This is because the measure is straightforward and possible to implement. Furthermore avoiding fossil fuels can be seen acceptable both in farm level and in society. The probability of the use got almost the same points than in other specific measures. The broadness of implementation was seen rather high because it gives opportunities for extensively in agricultural production. Also the measure was considered to be most effective reducing emissions among the three specific questions.

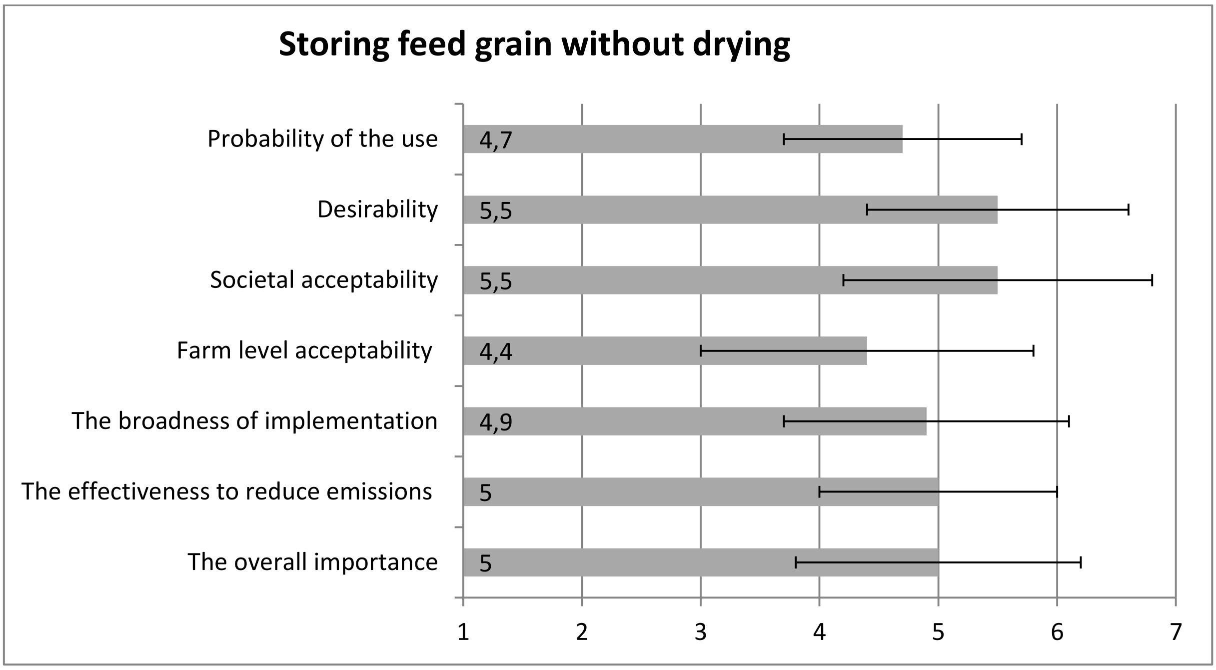

Figure 3. The expert panel view on storing feed grain without drying

Discussion and Conclusions

This paper focuses on the improvement of using both quantitative and qualitative approaches in researching the climate change mitigation policy measures within agriculture. Our attempt was performed by integrating interactively farm level model simulations with the future views of an expert panel. The main idea in combining an expert evaluation method and quantitative simulations is to add in more information than judgements only to enhance expert deliberation in the Delphi process. In addition, the idea was to deliver both general future information, and more specific evaluations of the studied measures. The data base requirements are more detailed in order to be able simulate the farm level functional changes that may occur.

The benefits of combining farm level modelling and Delphi method materialise from more accurate base of expert evaluation. The model simulations give detailed results of the impacts of mitigation policy measures on the farm level. The model simulations also give insight of the mitigation potential and the panellists can compare different measures with each other, and therefore, give their opinions based on comparison. The challenge of farm level modeling is to conduct similar analysis within full range of mitigation policy measures. This is because farm level research calls for more specific farm level data in order to represent and formulate the research question in each case. The data is not always available.

In this study the combining approach was attempted concerning three chosen mitigation policy measures. This approach calls for competence in the methods used in order to succeed in entity. For example, the simulation results must be presented in straightforward way in Delphi rounds in order to achieve realistic evaluation results and avoid respondent fatigue. In this study the simulation results were presented with framings dealing with questions as to "how much would a reduction of one carbon dioxide equivalent ton cost?" or "what is the potential reduction percent of the measure in the greenhouse gas emissions in agriculture, LULUCF and energy sectors?" The straightforwardness is especially important if the Delphi round is conducted with online questionnaire and further information is more difficult to give in a user-friendly fashion. If the questionnaire is completed in face-to-face situations, arisen questions are easier to answer.

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Appendix A: The used questionnaire format

Mitigation policy measure: requiring farms with organic soils to cultivate perennial grass on them:

Perennial grasses reduce the GHG-emissions of the organic soils. According the WRB-classification (The World Reference Base for Soil Resources), there were approximately 330 000 hectares of organic soils under cultivation in Finland in year 2009, of which 44% were cultivated by perennial grass and 56% by grain crops. Cattle farms had 114 000 hectares organic soils and 33 000 hectares of it was cultivated by grain crops. If the cattle farms would cultivate perennial grass on that 33 000 hectare, it would reduce N2O emissions by 123 783 carbon dioxide equivalent tons per year. At the same time the amount of the plain carbon dioxide emissions would be reduced by 193 600 tons per year. Together these emission reductions would designate 2,5% share of the agricultural emissions in agriculture and LULUCF sectors. Possible costs of the implementation of this measure would originate for example from the need of supplementary sow and increased plant protection costs caused by renewal of perennial grasses without grain in the crop rotation. Cattle farms need to replace the yield of the reduced grain cultivation area with bought grain or, when possible, by concentrating the cultivation of the grain crops to the mineral soils of the farm. In this case, the cost would originate from increased transaction e.g. logistic.

	Probability	Desirability	Societal acceptability	Farm level acceptability
Your opinion on the implementation of this measure in the future	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
	O O O O O O O	O O O O O O O	O O O O O O O	O O O O O O O
	small ... great	small ... great	small ... great	small ... great

	The broadness of implementation	The effectiveness to reduce emissions	The overall importance
Your opinion on the implementation of this measure in the future	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
	O O O O O O O	O O O O O O O	O O O O O O O
	small ... great	small ... great	small ... great

Varying Recipes for Climate Change Mitigation in Agriculture

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The climate and energy strategy of the European Union presents the aims for all economic sectors to reduce carbon dioxide emissions. In this paper, the objective is to study how various climate change mitigation measures will develop in agriculture in the light of the aims of climate and energy policy in up to 2030.

In this study, the Delphi method is used in the evaluation of climate change mitigation measures and their desirable and probable implementation in the future. The Delphi expert panel evaluated 20 different mitigation measures and their 1) probability of use, 2) desirability, 3) social acceptability, 4) broadness of use, 5) effectiveness in reducing emissions and 6) overall importance. The evaluated measures have influences on agricultural production in several ways. They can, for example limit farmers' possibilities to increase the organic soil area, improve the allocation of farm's arable land, change the technology in how to handle manure and generate changes in feeding or lead off to biogas production.

In total, 28 experts participated in the first round of the Delphi study. The first round was carried out using semi-structured interviews and the second feedback round is planned to conduct by an online questionnaire. Background information of the first round will be presented to the experts who responded with their views on developments of climate change mitigation measures between 2013 and 2030. According to the first round results five most important climate change mitigation measures were manure handling without extra field, biogas production, wintertime vegetation, focused nitrogen fertilization and precision farming.

Key words: Delphi method, climate change, mitigation measures, climate policy, energy policy, agriculture

Introduction

The climate and energy strategy of the European Union presents the aims for all economic sectors to reduce greenhouse gas (GHG) emissions (EU Commission 2014). For agriculture, this is more complicated than it would seem at a first glance. Greenhouse gas emissions from agriculture are reported under the United Nations Framework Convention on Climate Change and Kyoto Protocol under three sectors. Emissions of methane (CH_4) and nitrous oxide (N_2O) from production animals, manure and soils are reported under reporting sector "Agriculture". It accounted for 5.9. billion tn. of carbon dioxide equivalent (CO_2eq) currently in Finland. In addition, emissions of carbon dioxide (CO_2) from soils and liming are reported under sector "Land use, land use change and forestry" which accounts for 6.8 billion tn. CO_2eq and energy use on farms under sector "Energy" which accounts for 1.5 billion tn. CO_2eq in 2012. These emissions together are about 20% of the total GHG emissions on Finland (Regina et al. 2014).

The Finnish Government has published a Climate and Energy Strategy in which the agricultural sector is given a 13% reduction target for GHG emissions in 2005–2020 (TEM 2013). Specific measures are not defined in the strategy, but the main findings in recent Finnish studies have presented that it is almost impossible to mitigate emissions significantly without measures affecting the area of organic soils (Regina et al. 2009, Regina et al. 2014). In the light of the reduction goals this one target area may not be enough. If the area of cultivated organic soils was stabilised or even reduced and some other measures were also brought to practice, the total reduction could be significant but still likely less than 13% (Regina et al. 2014).

Against this background concerns related to climate change and potential mitigation measures, policy changes pose a key factor probably influencing agricultural development in the future. It is evident that climate change mitigation measures should be innovated and implemented to decrease emissions along the lines defined in the national and international climate policies. Therefore, in this study the composition of potential measure set up was gathered according to the relevant literature and this set up was divided into four themes, namely: 1) climate change mitigation measures concerning the animal and crop production and manure handling, 2) climate change mitigation measures decreasing soil nitrous oxide emissions, 3) climate change mitigation measures concerning land use changes and, furthermore 4) refined climate change mitigation measures. All considered measures are concrete actions available on the farm level. Wider policy measures, such as legal, economic and information measures are not considered in this study although such measures would be needed to enforce the adaptation of the measures of this study.

In this paper this set up of chosen 20 climate change mitigation measures are evaluated. The evaluation is based on a Delphi process in which the selected expert panel gave their views on the specified measures. The presented climate change mitigation measures consist of farm-level solutions and acts, as well as national level guidance related to climate change mitigation within agriculture. In this paper the first round results are presented as the second round is still ongoing.

Material and Methods

Method

In this study The Delphi method was used to gather expert views. The Delphi method aims to identify and explore alternative future possibilities, their probabilities of occurrence, and their desirability by tapping into the expertise of respondents (Linstone and Turoff 1975). The Delphi method gathers experts judgements by means of successive iterations of a given questionnaire, to show possible convergence of opinions and to identify dissent or non-convergence (Linstone and Turoff 1975). The Delphi method is considered especially useful for long-range matters as a scenario planning method in the field of foresight (Rikkonen & Tapio 2009). In this study the method consisted of two rounds. The first round was organised by face-to-face interviews and the second round by online questionnaire in where the results from the first round (especially arguments) were presented for the basis of re-evaluation.

The Delphi study examined agricultural climate change mitigation measures with respect to the future developments of climate change and energy policy objectives. In the first round questionnaire there were altogether 20 individual mitigation measures in the Delphi questionnaire, of which four where refined measures. The refined measures included extra information of the current status and of the implementation effects on the farm level and were therefore more specific than the basic measures. The function of the refined measures were to study does the extra information changes the answers of the participants. The expert panel was asked to evaluate the measures in seven dimensions:

1. the probability of use (how probably the measure will be implemented),
2. desirability (how desirable the panelist views the implementation of the measure),
3. societal acceptability (how would the society react to the implementation of the measure),
4. farm level acceptability (how the farms would react to the implementation of the measure),
5. the broadness of implementation,
6. the effectiveness in reducing emissions and
7. the overall importance.

A Likert scale of seven steps was used for each dimension, where 1 reflected low/small and 7 reflected high/large.

The expert panel overview

Delphi study is not a standard survey and rather than representative sample a comprehensive coverage of views is the principle for forming the expert panel (Kuusi 1999). In this study, the selection of the experts was made according to the expert matrix (Figure 1; Kuusi et al. 2006). First the areas of cognitive expertise (see Varho & Huutoniemi 2014) were defined: agriculture, renewable energy, climate, economy, technology, society, and natural sciences. Then the fields of the host organization representing social expertise were indicated: research, development and innovation (R&D&I), farm, administration, non-governmental organisations (NGOs), interest groups, advisory services, industry, media and trade. After selection, the experts were first approached by e-mail and then personally called to schedule an interview meeting. The questionnaire was sent by e-mail and asked to be returned electronically before the date of the interview. The interviews were conducted as face-to-face sessions in all except two cases, in which Skype phone call was used. The experts were asked to focus on the research issues within their own expertise. The first round questionnaire was sent to 36 experts, of whom 28 returned it.

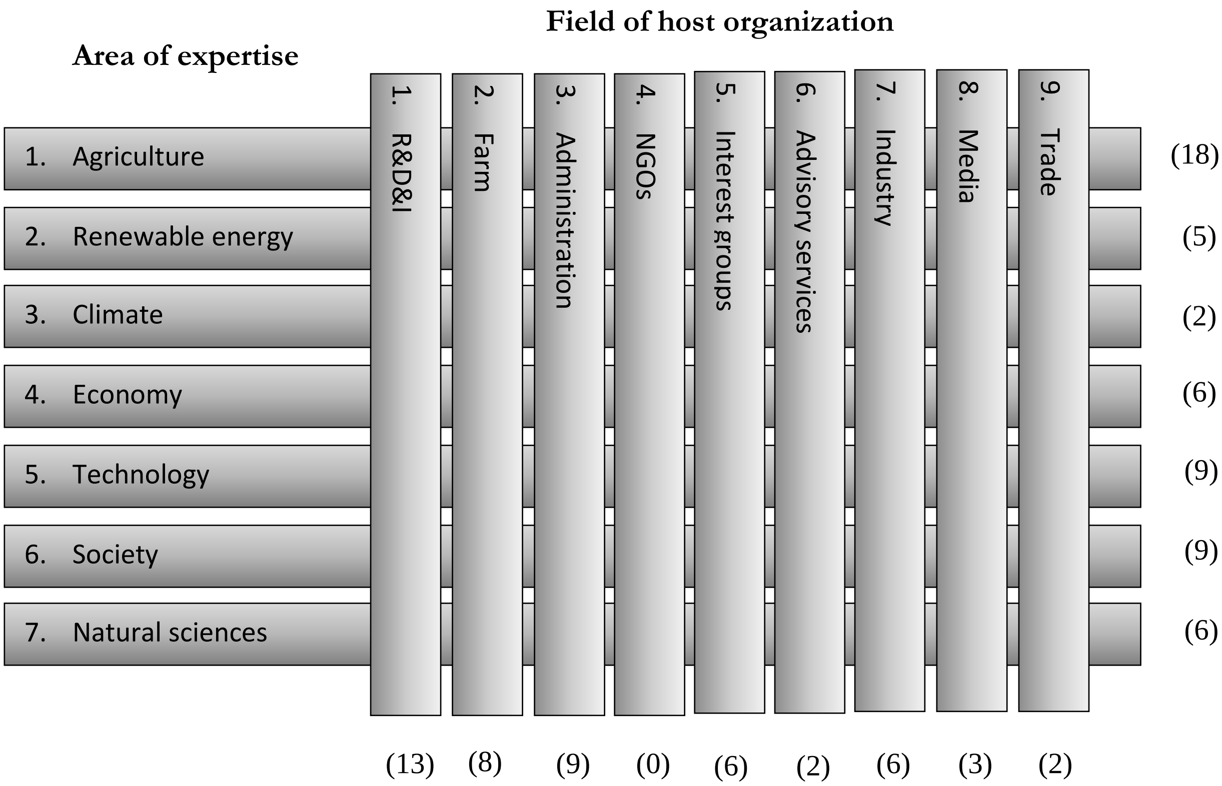

Figure 1. The expertise matrix of the Delphi study.

As the expert selection is one of the most critical phases of the Delphi method, in the following the panel is presented more in-depth. Figure 1 shows the respondents' area of expertise and the fields of their host organizations. It is noteworthy that respondents could select more than one area of expertise and host organization. Eight of the respondents had purely agricultural expertise and ten respondents had agricultural expertise in addition to having expertise in some other area. Three of the respondents had purely technological competence and six respondents had technological expertise in addition to some other one. Administration and R & D & I were the most represented fields among the host organizations. Seven respondents had a farm in addition to being active in some other professional field or host organisation. Seven respondents were active in the R & D & I field in addition to another field. There were no respondents from NGO organizations in the first round which calls for adding to the second round of inquiry.

The respondents were comprised of experts of different fields (Figure 1.). In this study the criterion of selection of the expert panel also meant that the education level was relatively high. Almost 60 per cent of the respondents participated in agriculture and rural work daily and 93 per cent at least once a month. 40 per cent of the respondents operated purely on the national level and 22 per cent on the international level. 86 per cent of the respondents had completed a university-level degree. 36 per cent of the respondents had either licentiate or doctoral degree. The responding experts have quite a high education compared to the average level of education rate in Finland.

Results

Figure 2 shows how the respondents estimated the 20 mitigation measures' overall importance. We examined more closely the five most important measures and two additional measures, which had the largest standard deviations of the overall importance of the studied measures evaluated by the expert panel. The five most important measures overall were: 1) manure handling without extra field, 2) biogas production, 3) wintertime vegetation, 4) focused nitrogen fertilization and 5) precision farming. The two measures with the largest standard deviations were 6) reduction in meat consumption and 7) the prohibition of land clearing of organic soils. Next the desirability and probability of use of these top seven measures will be examined in more detail. These two basic dimensions in futures studies (see Amara 1981) were selected to study the broadness of the gap between the probability and the desirability of implementing the measures and the implications of the gap.

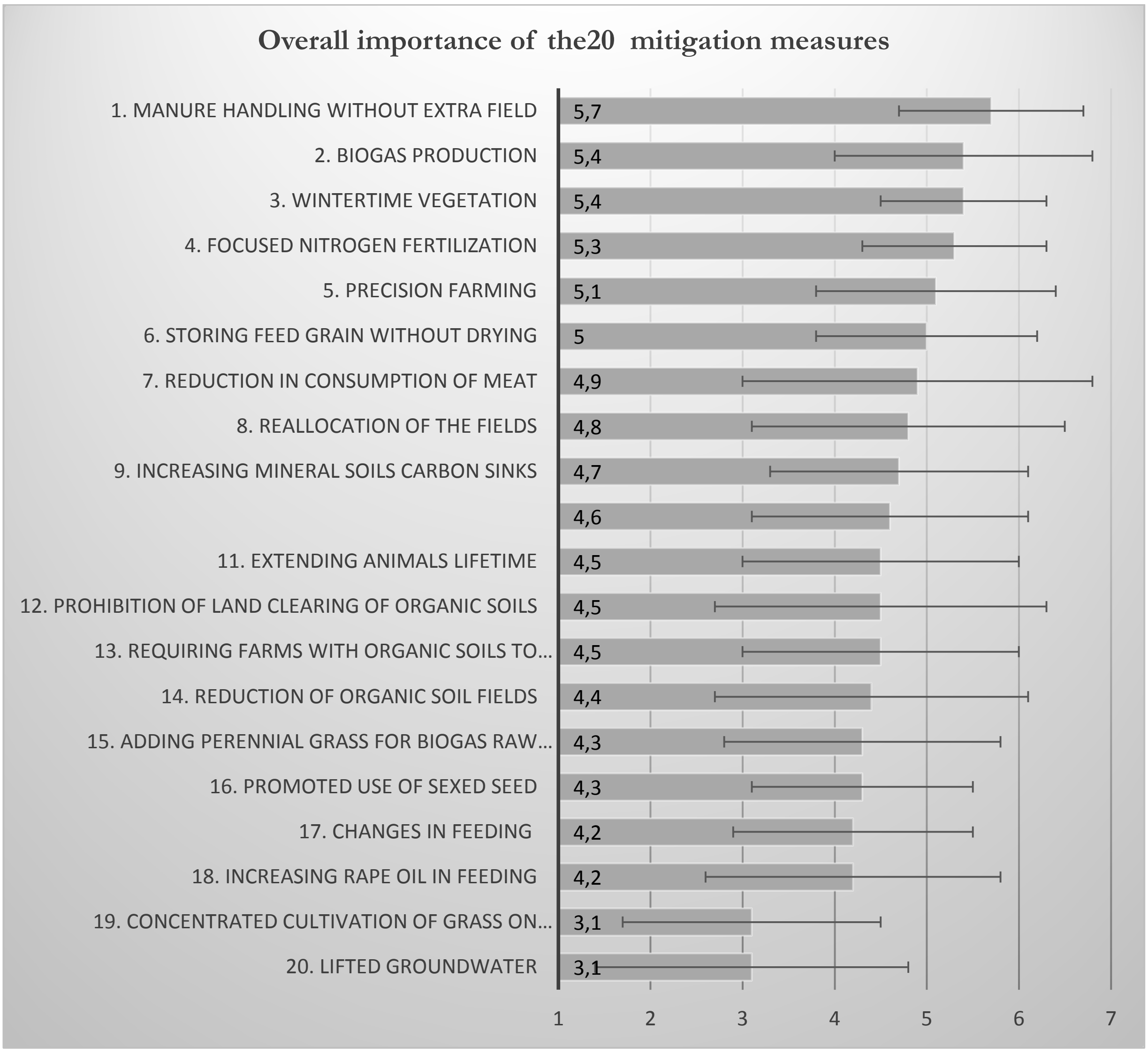

Figure 2. Overall importance of the 20 climate change mitigation measures, evaluated by the expert panel.

The top seven climate change mitigation measures are illustrated in Figure 3 by their desirability and probability of use. The values of standard deviation are shown in parentheses. Manure handling without extra field (±1) and biogas production (±1,1) were seen as desirable at the average value of six. The reasons for this were primarily the increased and advanced way to recycle the nutrients, more versatile entrepreneurships and the possibility to increase the self-sufficiency in energy and fertilizer consumption. The probability of the use was seen equal to manure handling without extra field (±1,2) and biogas production (±1,4) at the average value of five. The probability of the use was reduced due to the current lack of technology and high implementation costs as well as the speculations of the changes in subsidies in the future.

Desirability of the wintertime vegetation (±0,8) was very close to the probability of use (±0,6). Respondents felt this climate change mitigation measure to be natural and it was seen to be widely used already making it easier to be adopted more widely. Also focused nitrogen fertilization was seen almost as desirable (±0,9) as probable to use (±0,7) on average. Respondents saw that the climate change mitigation measure is widely used already and therefore it is a potential way to mitigate climate change in the future, too. A few respondents had a contrary view and argumented that there is a little to improve using this climate change mitigation measure because the focused nitrogen fertilization has already been economically optimized in the farms.

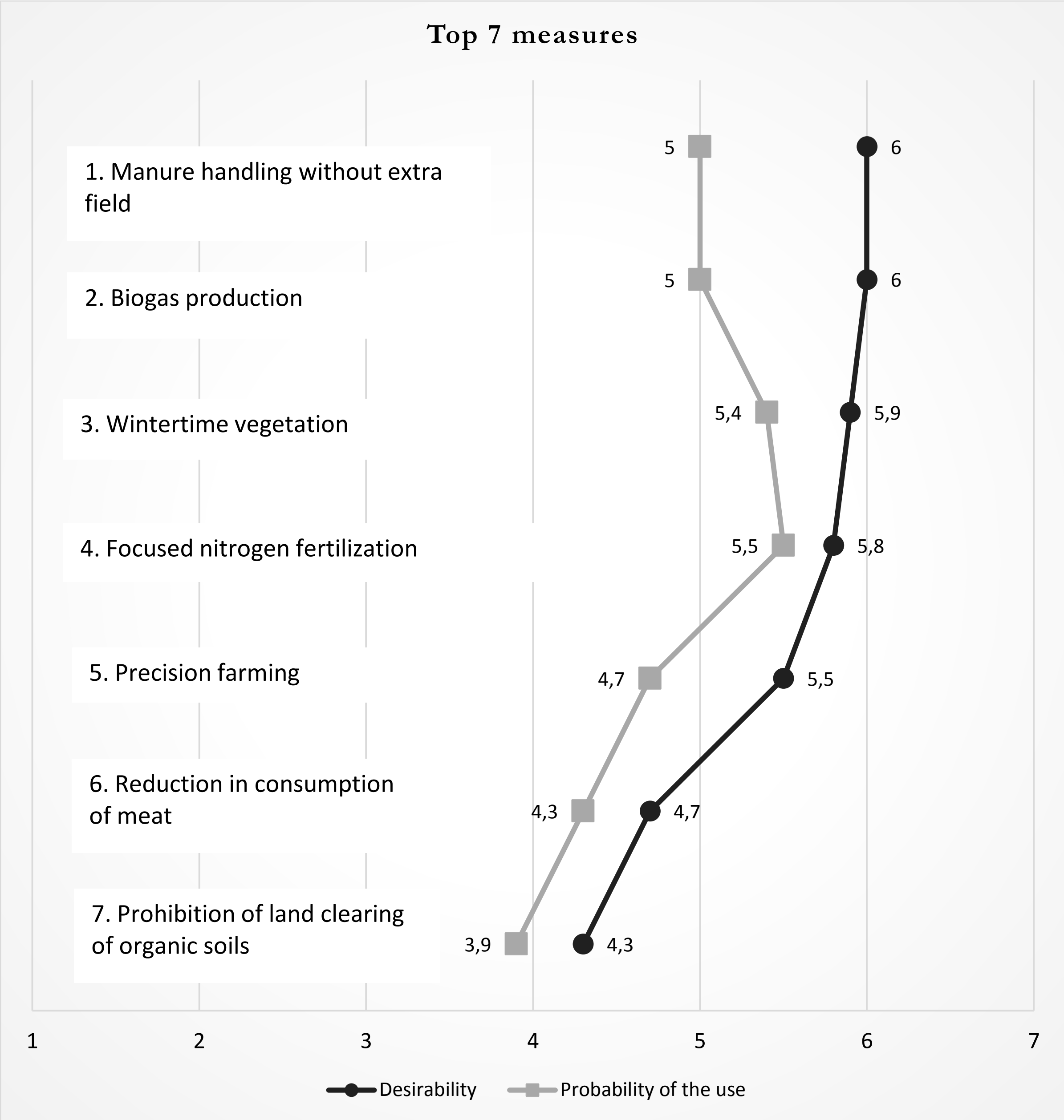

Figure 3. The mean values of desirability and probability of use of the top 7 climate change mitigation measures.

Precision farming was considered desirable (±1,2) among the respondents because of its favorable effect to increase nutrient balance and its resource efficiency (economy). The probability of the use (±1,1) was decreased mostly by the high cost of the modern technology. The respondents did not believe that this technology would progress quickly enough so that the climate change mitigation measure could be cost-effectively used more widely in the next 20 years.

The desirability (±1,8) of reducing meat consumption divided the respondents' answers. Some of the respondents saw reduction in meat consumption to be desirable because of its negative environmental and health effects. Some of the respondents were not in favor of decreasing the meat consumption, because it would lead to a reduction in production volumes in Finland. In addition naturally grown grass would then be unused. At the same time it would hinder business. Few of the panelists feared that if this kind of measure would be implemented, meat imports from the third-world countries would increase. Thus the emissions of production would only be shifted elsewhere and not be reduced as desired. Many respondents also said that this kind of measure would be difficult to implement by the administrative means. That is why many of the experts considered it hard to be implemented, though it is an important and easy way to reduce emissions. The climate change mitigation measures to reduce meat consumption were not seen probable (±1,4) on average. This was considered because of the slow changes in consumer behavior and the fact that this kind of climate change mitigation measure is against the free trade agreements (EU and WTO).

Desirability of prohibiting land clearing of organic soils (±1,5) was seen among the panelists a little higher than its probability of use (±1,9) on average. Respondents who resisted the implementation of this measure did not see appropriate to intervene and limit the entrepreneurs' possibilities to run their businesses. It is noteworthy that some of the respondents did not support any sanctions and considered them undesirable by nature. Those respondents who supported the implementation of the measure and thereby regarded it as a desirable measure to possess a great potential to mitigate the climate change.

Discussion and conclusions

In this study a set up of chosen 20 climate change mitigation measures were evaluated. The evaluation is based on an ongoing Delphi process where a selected expert panel gave their future views on specified measures. The measures consist of farm-level solutions/measures, partly requiring national level guidance related to climate change mitigation within agriculture.

The most preferred climate change mitigation measures were manure handling without extra field area and biogas production. According to the results there was more deviation in the answers of the farm level acceptability in the measure implementation. Especially the dependence on subsidies decreased the farm level acceptability of measures. Furthermore the technology that some of these measures called for was considered expensive and also insufficient. The complexity of the use of technologies causes anxiety, and therefore makes it more difficult to adopt. Biogas production was seen as very effective in reducing emissions, but the overall influence on emission reduction was still considered modest. This was because the capacity of biogas has not widely increased in recent years and the expert panel considered that it will not increase drastically before 2030. Also the societal acceptance was seen rather modest due to the lack of support and promotion of small-scaled biogas production.

The employ of precision farming helps to achieve information about soil structure which helps in reducing emissions. The potential is there, but the technology itself is costly. The employ of precision farming was also considered to improve the soil structure and prevent erosion. At the same time it restricts the selection of cultivated plants. The focused nitrogen fertilization was seen as integral part of precision farming.

The reduction of the meat consumption was not seen as a solution to reduce emissions if the level of production does not change. One-sided reduction policy was also considered to restrict agricultural and food businesses and does not fit to the principles of free trade and EU internal market agreements. Advising consumers about meat consumption issues were seen as a more relevant way. The potential to reduce emissions from organic soils was widely known by the panel. Still, the implementation of prohibiting land clearing was not seen realistic. This kind of climate change mitigation measure would be an unconscionable in relation to the global food security situation, and it also restricts farmers' possibilities to develop their business. It also treats farmers unfairly in different areas and production lines. However, many of the panelists saw that this kind of climate change mitigation measure could be implemented in the EU area in the future.

Overall, many of the scrutinised climate change mitigation measures were considered highly potential in reducing greenhouse gas emissions. Many of them are still hard to implement through policy guidance because farms are heterogeneous and the cost efficiency of measures is not clear. Some of measures also set restrictions to land use of landowners which was not seen desirable. Throughout the different measures, increasing farmers' understanding and competence of managing natural processes sustainably (especially nutrient cycle) was considered important. Therefore the roles of advisory services and education are essential.

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Reporting Obligations under the Climate Regime: One Step Forward and Two Steps Back

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The last decisions of climate Conferences of the Parties (COP) heading towards the adoption of the 2015 Agreement have strengthened States reporting obligations under the United Nations Framework Convention on Climate Change (UNFCCC) regime. These reinforced obligations testify of the importance of reporting as a method largely used for ensuring compliance. However, States parties do not always comply with their reporting obligations, or when they do, often submit their reports really late. Thus, the COP is obliged to call regularly for their complete and timely submission. At a time when the regime is negotiating its very future with the 2015 Paris COP in the horizon, this paper aims at assessing the extent and purpose of reporting obligations in the regime. The rationale is that reporting is vital for any international regime and, as such, the climate reporting mechanism must be strengthened.

Introduction and Background

"Among the monitoring procedures developed in major environmental conventions, reporting obligations occupy a privileged position" (Lanfranchi 2007, 157). Two elements explain this central position. First of all, reporting obligations are both "a centrepiece in the gathering of information and a cornerstone of the whole reviewing mechanism" (Bannelier-Christakis 1998, 91)[1]. Then, they play an important part in the shift of the control of compliance from States to international bodies. Indeed, "historically, monitoring the implementation of international law was […] entrusted in the State itself […] and other States, such as co-contracting parties in the case of a convention"(Maljean-Dubois 2007, 18). However, the more multilateral environmental agreements have developed themselves, the more States have been pushed in second place in this area. The aim is to introduce more objectivity in the control of compliance. Thus, it is today extremely rare to find an environmental agreement that does not develop a body dedicated to the management of the reporting system.

In the climate regime, the foundations of the reporting system lie in the UNFCCC[2]. The Convention indeed requires parties to submit information. First of all, they are asked to "*develop, periodically update, publish and make available to the Conference of the Parties* […] *national inventories of anthropogenic emissions by sources and removals by sinks of all*

[1] See also: Kiss 2006, 229; Chayes, Chayes, Mitchell 2000, 46-47.
[2] UNFCCC, 1771 UNTS 107, (entry into force 21.3.1994).

greenhouse gases […] *using comparable methodologies to be agreed upon by the Conference of the Parties*"[3]. Then, they shall communicate information on steps taken or envisaged for the implementation of the Convention[4]. The development of a reporting system was also an important question of the negotiations of the 1997 Kyoto Protocol[5]. The idea was to connect reporting obligations of the Protocol to article 12 of the Convention but also to all the COP decisions that had been adopted since 1992 regarding this question (Depledge 2000, §93; Lanfranchi 2007, 158). Thus, the reporting system of the Protocol covers the same type of information than the 1992 obligations: emissions/removals by sinks and measures/policies adopted to implement the Protocol (Lanfranchi 2007, 159). Furthermore, parties to the Protocol only need to add their information to communications submitted under the Convention rather than establishing entirely specific reports[6]. The only difference between the two mechanisms is that information submitted under the Kyoto Protocol obviously cover data on the reduction commitments of Annex I parties and other particular obligations of the 1997 instrument.

The COP of the Convention and Meeting of the Parties (COP-MOP) of the Protocol often emphasize that "the national communications and annual greenhouse gas inventories submitted by Parties […] are the main source of information for reviewing the implementation of the Convention"[7]. Thus, reporting obligations are recognised as a very important element of the regime. In turn, this importance explains their extensive development in the climate arena and led the COP and COP-MOP to reinforce them in the recent years. The adoption of the 2010 Cancún Agreements and 2011 Durban Decisions can today be regarded as the foundations of the strengthened reporting system applicable under the climate regime as it will be developed below.

But despite this reinforcement and while acknowledging a considerable improvement in the timeliness of the submission of national communications, the COP and COP-MOP still have to urge and request different parties to submit their reports on the implementation of the Convention and Protocol in due course[8]. Since the *raison d'être* of reporting is to allow a regular analysis of the global implementation of conventions by parties and, consequently, a review of the progress made in the pursuit of the treaty's objectives (Sachariew 1991, 41), it is certain that any delay in the submission or any lack of national communications will prevent the regime from reacting to

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[3] UNFCCC, note 2 above, art. 4§1a) and 12§1a).
[4] UNFCCC, note 2 above, art. 12§1b).
[5] Kyoto Protocol to the United Nations Framework Convention on Climate Change, 2303 UNTS 148 (entry into force 16 February 2005).
[6] Kyoto Protocol, note 5 above, art. 7.
[7] See, for instance: *Decision 9/CP.16 National communications from Parties included in Annex I to the Convention*, 15 March 2011, Doc. FCCC/CP/2010/7/Add.2, Preamble §3; *Decision 20/CP.18 Status of submission and review of fifth national communications from Parties included in Annex I to the Convention and compilation and synthesis of fifth national communications from Parties included in Annex I to the Convention*, 28 February 2013, Doc. FCCC/CP/2012/8/Add.3, Preamble §3; *Decision 7/CMP.8 Supplementary information incorporated in national communications from Parties included in Annex I to the Convention that are also Parties to the Kyoto Protocol and submitted in accordance with Article 7, paragraph 2, of the Kyoto Protocol*, 28 February 2013, Doc. FCCC/KP/CMP/2012/13/Add.2, §4; *Decision 22/CP.19 Sixth national communications from Parties included in Annex I to the Convention*, 31 January 2014, Doc. FCCC/CP/2013/10/Add.2, Preamble §3.
[8] See, for instance: *Decision 10/CP.13 Compilation and synthesis of fourth national communications*, 14 mars 2008, Doc. FCCC/CP/2007/6/Add.1, §1-2; *Decision 9/CP.16*, note 12 above, §1-2; *Decision 20/CP.18*, note 12 above, §1-2; *Decision 22/CP.19*, note 12 above, §1.

situations or to improve its general implementation. Such consequences would, in turn, prevent the regime from moving towards a better effectiveness.

At a time when parties are negotiating the future of the climate regime, with the 2015 COP – which should see a new protocol, legal instrument or agreed outcome with legal force adopted[9] – in the horizon, this paper aims at assessing the extent and purpose of reporting obligations in the regime. While maintaining that a strong reporting system is vital for the climate regime, we are of the view that different improvements are needed to strengthen the actual reporting mechanism both for parties and within the regime.

Material and Methods

Analysing the extent and purpose of the reporting obligations under the climate regime and assessing their weaknesses requires looking back at the dispositions of both the Convention and the Protocol, especially since they include a differentiation in the respective obligations of developed and developing countries. However, the focus of our assessment shall be on the current climate reporting system created by the 2010 Cancún Agreements and 2011 Durban Decisions and applied ever since through various COP decisions. Our objective is to conduct a comprehensive assessment of the reporting system showing how the recent COP decisions have strengthened the whole mechanism. Meanwhile, the status of submission of national reports, referred to in COP decisions, will be analysed in order to determine if the strengthening of the reporting mechanism has led to improved submissions of national reports. This impact must indeed be assessed since a better compliance with reporting obligations means that better information is provided to the regime.

Yet, the empirical observation of persistent difficulties in the submission of national communications, even after 2010/2011, will lead the author, in a second phase, to question the improvements that could be developed to improve compliance with the reporting obligations of the climate regime. Such improvements will be considered regarding both the parties and the regime itself.

Results

Reporting obligations under the climate regime

Before analysing in detail the current reporting system of the climate regime, it is necessary to come back to its foundations, established by the Convention and the Protocol. When studying the different dispositions of both treaties, the original reporting system of the climate regime appears as follows:

[9] *Decision 1/CP.17 Establishment of an Ad Hoc Working Group on the Durban Platform for Enhanced Action*, 15 March 2012, Doc. FCCC/CP/2011/9/Add.1, §4.

	Developed / Annex I Countries	Developing / Non Annex I countries	Least developed States
UNFCCC	**Article 12§1a), b) and c)** - National inventory of emissions and removals; - Description of steps taken to implement the Convention; - Other information relevant for the achievement of the objective of the Convention. **Article 12§2a) and b)** - Detailed description of policies and measures taken to implement Art. 4§2; - Specific estimate of effects that policies and measures will have on emissions and removals; **Article 12§3** - Information on financial assistance, adaptation to climate change and technology transfer; **Article 12§5** - Initial communication within six months of entry into force.	**Article 12§1a), b) and c)** - National inventory of emissions and removals; - Description of steps taken to implement the Convention; - Other information relevant for the achievement of the objective of the Convention. **Article 12§5** - Initial communication within three years of entry into force; **Article 12§7** - Provision of technical and financial support.	**Article 12§1a), b) and c)** - National inventory of emissions and removals; - Description of steps taken to implement the Convention; - Other information relevant for the achievement of the objective of the Convention. **Article 12§5** - Initial communication at the date they choose; **Article 12§7** - Provision of technical and financial support.
Kyoto Protocol	**Article 7§1 and 2** Information demonstrating compliance with commitments under the Protocol.		

Thus, in accordance with the principle of common but differentiated responsibilities inscribed in Article 3 of the UNFCCC, thorough reporting obligations are placed upon developed countries. Despite this element, the operating mode of the UNFCCC and the Protocol shows the real "*intertwining of both reporting systems*" (Lanfranchi 2007, 160) under the regime.

Building on the experience drawn from the Convention and the Protocol, recent COP and COP-MOP decisions (adopted in Cancún, Durban, Doha and Warsaw) have organised a complete transformation of the climate reporting mechanism. The 2010 Cancún Agreements have started by rebuilding the entire mechanism regarding obligations of developed and developing States. The COP has designed a mechanism that should be "*robust and* [able] *to generate credible information on and confidence in mitigation targets and actions*" (Rajamani 2012, 514). The Subsidiary Body for Implementation (SBI) is confirmed as a central actor since it is in charge of reviewing the submitted data. The Durban Decisions have built upon this basis and strengthened the 2010 outcome (Rajamani 2012, 501). Acknowledging the reporting mechanism as modified in 2010 and 2011, the 2012 Doha Decisions furthered its strengthening by adopting the "common guidelines for the reports of developed countries"[10]. Meanwhile, the COP-MOP of the Kyoto Protocol asked Annex I countries to keep adding supplementary infor-

[10] *Decision 19/CP.18 common tabular format for "UNFCCC biennial reporting guidelines for developed country Parties"*, 28 February 2013, Doc. FCCC/CP/2012/8/Add.3.

mation in their communications[11]. Finally, the Warsaw Decisions took the same path than the 2012 decisions. Thus, recalling Decision 1/CP.16 that decided to enhance the reporting from non-Annex I Parties, they have decided to continue the Consultative Group of Experts on National Communications from Parties not included in Annex I to the Convention for a period of five years[12]. They also adopted the guidelines for domestic MRV of nationally appropriate mitigation actions by developing countries[13] and launched a programme for the revision of the reporting guidelines applicable to the communications of developed countries[14]. The reporting system designed by the Cancún Agreements, Durban Decisions and following instruments appears thus:

	Developed / Annex I Countries	**Developing / Non Annex I countries**	**Least developed States**
2010, 2011, 2012 and 2013 COP Decisions	**Decision 1/CP.16 §44** - International assessment of emissions (IAR) and removals related to quantified economy-wide emission reduction targets. **Decision 2/CP.17 Part. II, A, §13** - Biennial reports on mitigation actions and the implementation of the Convention. **Decision 2/CP.17 Part. II, A, §14** - Full national communications with information on GHG emissions, policies and measures, GHG projections, vulnerability and adaptation to climate change, financial assistance and technology transfer to non-Annex I Parties, and actions on raising public awareness on climate change; every four years.	**Decision 1/CP.16 §63-64** - International consultations (ICA) and analysis of biennial reports. **Decision 2/CP.17 Part. II, B, §41** - Biennial reports with information on their mitigation actions and steps taken or envisaged to implement the Convention.	**Decision 2/CP.17 Part. II, B, §41**a) - Biennial update reports at their discretion.

Thus, decisions adopted during the four last COP and COP-MOP of the climate regime all contribute to the strengthening of the reporting obligations placed upon member States by the Convention. Information required are not so much different than what the UNFCCC required. However, the timeframe for the submission of national reports is precisely set with biennial reports for developed and developing countries and national communications every four years for the former. Moreover, a strengthened review process of national reports and communications is created with the IAR for developed and ICA for developing countries. The importance of the

[11] *Decision 7/CMP.8*, note 7 above.
[12] *Decision 19/CP.19 Work of the Consultative Group of Experts on National Communications from Parties not included in Annex I to the Convention*, 31 January 2014, Doc. FCCC/CP/2013/10/Add.2.
[13] *Decision 21/CP.19 General guidelines for domestic measurement, reporting and verification of domestically supported nationally appropriate mitigation actions by developing country Parties*, 31 January 2014, Doc. FCCC/CP/2013/10/Add.2.
[14] *Decision 23/CP.19 Work programme on the revision of the guidelines for the review of biennial reports and national communications, including national inventory reviews, for developed country Parties*, 31 January 2014, Doc. FCCC/CP/2013/10/Add.2.

availability of regular and accurate information explains the strengthening of the reporting system under the UNFCCC. Yet, one can also notice an increasing parallelism between the obligations of developed and developing countries, starting with the wording of these obligations. Here it seems that this evolution mirrors the changes in the very conception of the regime itself, especially concerning the practice of differentiation.

Differential treatment and the evolution of reporting obligations

Developed in 1992 and 1997, that is to say at the beginning of the climate regime, reporting obligations under the UNFCCC and the Kyoto Protocol are characterised by a strong differential treatment between parties. These obligations are indeed clearly separated between those of developed and Annex I countries on one side and those of developing countries and non-Annex I parties on the other. Thus, reporting obligations only mirror the image of the core obligations of both instruments, which are divided in the same manner.

And yet, a similar analysis applies to the reporting mechanism launched by the Cancún Agreements. One of the main stumbling blocks of recent climate negotiations is indeed the definition of commitments – or at least stronger actions – from non-Annex I countries and especially emerging economies such as the BASIC[15] countries (Maljean-Dubois & Wemaëre 2013, 16; Rajamani 2008, 49-50). Thus, during the Durban COP, China finally agreed that climate change was no longer a developed countries issue (Lin 2011, 297; Bodansky 2012, 2) and emerging economies accepted to take part in the negotiations of a future binding agreement under the Durban Platform, a process that is now ongoing. However, the Doha and Warsaw COP did not bring any noticeable progress on this issue (Maljean-Dubois & Wemaëre 2013, 16). And yet, mitigation actions – if not commitments – of developing countries have become part of the regime event though they are still voluntary[16]. Thus, an increasing parallelism between both categories of countries obligations is appearing in the regime[17].

Now, it is possible to notice the same growing parallelism regarding reporting obligations. Indeed, while differential treatment remains – obligations being placed upon either developed or developing countries – there are noticeable changes. If developed countries are the sole to report on mitigation commitments, both groups indeed report on mitigation actions. Furthermore, the wording of reporting obligations has evolved. For instance, it is stated in the decisions that developing countries should comply with their obligations "*consistent with their capabilities and the level of support provided*"[18] and should take into account "*their development priorities, objectives, capacities and national circumstances*"[19]. However, the Durban decision also stated that developed countries shall comply with theirs taking into account their national circumstances[20]. And yet, the COP had never taken the situation of developed coun-

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[15] BASIC: Brazil, South Africa, India and China.

[16] See, for instance, *Decision 1/CP.19 Further advancing the Durban Platform, 31 January 2014, Doc. FCCC/CP/2013/10/Add.1*, §4f).

[17] See, for instance, Heyvaert, Veerle (2009), Levelling Down, Levelling Up, and Governing Across: Three Responses to Hybridization in International Law, *European Journal of International Law*, Vol. 20(3), 647-674.

[18] *Decision 2/CP.17 Outcome of the work of the Ad Hoc Working Group on Long-term Cooperative Action under the Convention*, 15 March 2012, Doc. FCCC/CP/2011/9/Add.1, Part. II, B, §41a).

[19] *Decision 2/CP.17*, note 18 above, Part. II, B, §41b).

[20] *Decision 2/CP.17*, note 18 above, Part. II, A, §13.

tries into account before but did it again in 2012 concerning their financial contributions[21]. Finally, the review processes of IAR and ICA have various similarities starting with their common objective of transparency and comparability. They should indeed promote constructive and non-confrontational interactions rather than punitive elements. Meanwhile, in both cases, the SBI conducts the supervision of the process.

Thus, the evolution of core obligations regarding climate change has had a real impact on the recasting of reporting obligations. The search for commitments or at least reinforced mitigation actions to be placed upon emerging economies and some developing States – a subject that is at the core of the post-2012 and post-2020 negotiations – led to a reinforcement of reporting obligations of both developed and developing countries. More accurately, the evolution of reporting obligations seems to mirror the changes in the core obligations of the regime. This increasing parallelism, which translates a certain transformation of differential treatment, can be explained by the characteristics of reporting obligations. Whatever the situation of parties may be, national communications "*are the main source of information for reviewing the implementation of the Convention and its Kyoto Protocol by those Parties*"[22]. Thus, the functioning of COP and its bodies is entirely based on the feedback on implementation they receive from States. Therefore, compliance with reporting obligations is a crucial question for the regime.

Compliance with reporting obligations

Before the changes brought by the Cancún and Durban conferences, the COP of the Convention and COP-MOP Protocol had to urge parties, at various sessions, to submit their national communications and to do so in due time[23]. Since the 2010 Cancún Agreements, the COP has acknowledged a considerable improvement in the timeliness of the submission of national communications, which is an important progress for the regime. However, this trend is not yet secured. Thus, the COP is still forced to call regularly for the timely and above all complete submission of national reports and communications[24]. This situation is very similar to various others multilateral environmental agreements, which also face difficulties with the submission of national reports.

The persistent difficulties faced by the climate regime concerning compliance with reporting obligations thus raise the question of remedies. And remedies needs to be developed since any paralysis, failure or even delay in

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[21] *Decision 1/CP.18 Agreed outcome pursuant to the Bali Action Plan*, 28 February 2013, Doc. FCCC/CP/2012/8/Add.1, Part. V, §63.

[22] *Decision 9/CMP.9 Supplementary information incorporated in sixth national communications submitted in accordance with Article 7, paragraph 2, of the Kyoto Protocol*, 31 January 2014, Doc. FCCC/KP/CMP/2013/9/Add.1, Preamble.

[23] See for instance: *Decision 30/CP.7 Third compilation and synthesis of initial national communications from Parties not included in Annex I to the Convention*, 21 January 2002, Doc. FCCC/CP/2001/13/Add.4, §1-2; *Decision 2/CP.8 Fourth compilation and synthesis of initial national communications from Parties not included in Annex I to the Convention*, 28 March 2003, Doc. FCCC/CP/2002/7/Add.1, §3; *Decision 4/CP.8 National communications from Parties included in Annex I to the Convention*, 28 March 2003, Doc. FCCC/CP/2002/7/Add.1, §1-3; *Decision 1/CP.9 National communications from Parties included in Annex I to the Convention*, 22 April 2004, Doc. FCCC/CP/2003/6/Add.1, §4; *Decision 8/CP.11 Submission of second and, where appropriate, third national communications from Parties not included in Annex I to the Convention*, 30 March 2006, Doc. FCCC/CP/2005/5/Add.1, §1-3; *Decision 10/CP.13*, note 13 above, §1-2; *Decision 8/CMP.3 Compilation and synthesis of supplementary information incorporated in fourth national communications submitted in accordance with Article 7, paragraph 2, of the Kyoto Protocol*, 14 March 2008, Doc. FCCC/KP/CMP/2007/9/Add.1.

[24] See, for instance, *Decision 9/CP.16*, note 12 above, §2; *Decision 20/CP.18*, note 12 above, §1-2; *Decision 7/CMP.8*, note 12 above; *Decision 22/CP.19*, note 12 above, §1.

the functioning of the reporting system could involve consequences for the capacity of reaction and ultimately the effectiveness of the whole climate regime.

Discussion and Conclusions

According to the climate Secretariat, "accurate, consistent and internationally comparable data on GHG emissions is essential for the international community to take the most appropriate action to mitigate climate change, and ultimately to achieve the objective of the Convention"[25]. Despite this importance, the reporting mechanism is not "authorized or tailored to address the issue of 'adequacy' or 'ambition' of these targets and actions in relation to the 2°C goal" (Rajamani 2012, 514). Therefore, the most central element regarding the fight against climate change thus remains outside the reviewing mechanism of the regime, a situation that is highly disputable.

This central question will obviously need to be addressed in the future since the effectiveness of the climate regime depends, from a great part, on the effectiveness and ambition of the reporting mechanism. Yet, two elements can be brought forward to support and improve this effectiveness the reporting mechanism as it is now. First of all, it is incontrovertible that "*the timely submission of national communications does not only depend on the good will of parties, but also on material and logistic means*" (Boisson de Chazournes, Laurence 1995, 57–58). If the lack of capacities impacts the timely submission of reports, then the strengthening of reporting obligations will create a new strain on developing countries capacities. Ultimately, the effectiveness of the mechanism will suffer from this situation since information on the implementation, by developing countries, of their obligations is important for the regime. One way to address this trend is to develop a better assistance for developing countries regarding their reporting obligations. The principal goal of international assistance is indeed to enable the recipient countries to comply with their obligations, among which are their reporting obligations[26]. Thus, in the case of developing countries, any strengthening of such obligations should be linked with a strengthening of financial and technical assistance for parties that cannot complete or submit their reports. Secured assistance – in the sense that assistance should be both adequate and predictable – will place developing countries in better position to comply with their reporting obligations. Thus, some elements of assistance must be included in the ongoing negotiation of the Measuring, Reporting and Verifying (MRV) system which is designed under the 2015 Climate Agreement to be adopted in Paris.

Then, a thorough reflection has to be conducted on the control of compliance with reporting obligations under the climate regime. Under the Kyoto Protocol, the Facilitative Branch of the Compliance Committee may provide "early warning" of potential non-compliance with methodological and reporting commitments relating to GHG inventories, and commitments on reporting supplementary information[27]; an outcome that was recently considered in the case of Austria, Croatia and Italy concerning their 2012 submissions, which were made available

[25] UNFCCC, National Reports, available at: <http://unfccc.int/national_reports/items/1408.php>.
[26] UNFCCC, note 2 above, art. 4§3; Kyoto Protocol, note 5 above, art. 11. See also the COP decisions quoted above, which regularly call for such assistance, for instance: *Decision 2/CP.17*, note 18 above, Part. II, B], §44.
[27] *Decision 24/CP.7 Procedures and mechanisms relating to compliance under the Kyoto Protocol*, 21 January 2002, Doc. FCCC/CP/2001/13/Add.3, Annex Part. IV, §6.

only in 2013[28]. Then, the Enforcement Branch is responsible for determining whether a party included in Annex I is not in compliance with, *inter alia*, "*the methodological and reporting requirements under Article 5, paragraphs 1 and 2, and Article 7, paragraphs 1 and 4, of the Protocol*"[29]. According to the rules of the Enforcement Branch, any Party not complying with reporting requirements must develop a compliance action plan[30]. In all cases, the Enforcement Branch will make a public declaration that the Party is in non-compliance and will also make public the consequences to be applied[31], the famous "*name-and-shame*" effect. Thus, the Compliance Committee of the Kyoto Protocol plays an important role on the implementation, by parties, of their reporting obligations. However, as the future of the Kyoto Protocol is in the balance in the post-2020 negotiations, the future of the Compliance Committee is uncertain as well. Under the UNFCCC, national reports of an Annex I Parties are subjected to an in-depth international assessment of emissions and removals conducted by expert teams under the SBI. Meanwhile, information submitted by non-Annex I Parties are considered by other expert groups, also set up by the SBI[32], through a process of international consultations and analysis. However, the SBI only has the power to make recommendations to the COP if an issue relating to reporting is discovered. It cannot act directly to deal with the situation that has been revealed by the experts. Thus, a strengthening of the reporting mechanism of the climate regime seems necessary. Without going as far as pleading for the setting of a compliance mechanism with punitive powers in case of non-compliance with reporting obligations, the 2015 MRV framework should, at least, be able to recognise situations on non-compliance and to provide remedies and hence facilitate compliance.

The Cancún and Durban COP have designed a reporting mechanism that is more complete than the 1992 obligations of the UNFCCC. The Doha and Warsaw conferences have helped completing this framework. However, it appears that improvements are still needed for the reporting mechanism to play its fundamental role with effectiveness. Thus, the 2014 Lima and 2015 Paris conferences will have to make their contributions to the improvement of the reporting obligations. The 2015 Agreement should especially establish clear rules of procedures regarding non-compliance with reporting obligations, bearing in mind that a facilitative approach is certainly the best remedy to ensure a return to compliance. Then, the reporting mechanism will play its part in reaching the ultimate objective of the Convention.

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[29] *Decision 24/CP.7*, note 28 above, Annex Part. V, §4b).
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Responding to Climate Change: Developing Water Resources Governance in Lao PDR

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Water resource management and development are becoming increasingly complex and demanding with the rapid increase in the water projects of different usages, especially as at the same time the challenges related to climate change, population growth, and urbanization are growing. Climate change occurrences in Lao PDR include an increase in temperatures, droughts and floods and changes in rainfall patterns, which are likely to be accentuated in the near future. The country is very vulnerable to the impacts of climate change due to its high socio-economic dependence on climate-sensitive sectors such as water and agriculture, and low adaptive ability associated with widespread poverty and weak technical and institutional capacity. Water resource management and planning are seen as necessary in order to tackle risks and challenges connected with the climate change and environmental challenges, such as scarcity of water and deteriorating water quality. The research paper focuses on analysing current water development, management and planning processes and related institutional and policy development from the perspective of climate change adaptation in Lao PDR. The aim is to examine how water resources governance can contribute to and increase the ability to respond to climate change related challenges.

Introduction and Background

The water sector including agriculture, transport, energy, and urban development are inherently vulnerable to climate risks (OECD 2009, 100). Climate change with higher water temperatures and changes in extremes (floods and droughts), is expected to have dramatic effects on water resources. Potential changes are expected in hydrology, moisture availability, spatial and temporal variations in magnitude of stream flow, dwindling of water levels with adverse effect on wetlands and ecosystem etc. As a consequence of this, water management has become a serious issue and identified as a global societal challenge. (Bates et al. 2008, 3; GFDRR & CIF 2011).

Climate change may create unprecedented impacts within the Southeast Asian region, exacerbating existing pressures on land, human settlement, and water resources. The Lao People's Democratic Republic (Lao PDR) hereafter referred to as Laos has been recognized as one of the Mekong countries that are most vulnerable to climate change impacts such as floods, droughts, and tropical cyclones due to its particularly high dependence on climate-sensitive natural resources and low adaptive capacity (ADB 2010, 20; Lao PDR 2010, 8).

Laos is a landlocked country in South-Eastern Asia with an estimated population of 6.6 million in 2012 (WB 2012). The total land area of the country is approximately 236,800 km^2 and some 80 percent of the country's area is composed of hills and mountains (FAO 2011). Governance in Laos means centralized one-party system – lack of political transparency and openness describes well its governance. The UN lists the country as one of the Least Developed with an average GDP per capita about US$1,130 (ADB 2013). Considerable progress has been made since the adoption of the New Economic Mechanism and the open-door policy in 1986. GDP was US$9.418 billion in year 2012 (WB 2012) and GDP of Laos grew by 7.6% in 2013 (ADB 2014, 205). The country's economic development is based on resource-based production, fueled by hydropower development for energy exports and mining, which has been an important driver behind the country's growth (ADB 2013). Poverty incidence has dropped from 33 percent in 2002 to approximately 28 percent in 2008 (ADB 2009, 239). The Lao government aims to graduate from the LDC list by 2020.

In Laos water is one the most important of its rich and varied resources and it is vital for the country's economic development (Lao PDR 2011; MoNRE 2012, 24). The estimated (internal) renewable water resources were 57,914 m^3/person/year in 2007, and the total renewable water resources are estimated at 333.5 km^3/year. Consequently, Laos has the highest per capita water availability in comparison with the other Asian countries (FAO 2011). The country's major subsectors of water use are irrigation, hydro-power, navigation, fisheries, and urban and rural water supply (Turner et al. 2009, 17). According to WEPA (2012) the use of agricultural water amounts to 93%, industrial use to 4%, and domestic use to 3% of total water use in Laos. Despite its vast available water supply little of it has been developed. In the past 30 years approximately 15% the country' hydropower potential has been developed (EPD webpage[39]).

Laos, as many other developing countries, has to without delay strive to both curb climate change and adapt to it, and while doing so also struggle to eradicate poverty and promote environmental protection and sustainable development. In terms of the water sector, it requires improving and developing water resources management in order to better secure e.g. water availability and sanitation, and preparedness for extreme weather events. (see MLTM et al. 2012; OECD 2013, 2; UNEP 2011, 2).

The paper describes some of the main features of the institutional and policy framework related to water resources management and climate change action and aims to illuminate challenges and gaps regarding climate change adaptation in the field of water management in Laos. Some of the most challenging issues are related to weak technical, human and financial capacity of government agencies, lack of reliable climate change data and concrete implementation of climate change policies.

The paper aims to increase understanding of the relationship of water resources management and climate change adaptation and of the importance of the water governance in the combat against climate change impacts. The paper is based on empirical research built on primary and secondary information and data analysis; official documents of the governmental organisations and relevant literature of the field, as well as interviews of the representatives of the government and experts.

Situation in Laos: Water Resources and Climate Change

It has been reported that a mean temperature increased at 0.1–0.3°C per decade between 1951 and 2000; rainfall trended downward during 1960–2000; and sea levels have risen 1–3 millimeters per year in Southeast Asia (ADB 2009, xxi). Extreme weather events (floods, storms and droughts) are expected to increase in intensity and frequency, causing extensive damage to property, productive assets, human life, and livelihood in the Region (ADB 2010, 4; Parry et al. 2007). Intergovernmental Panel on Climate Change (IPCC) predicts that future climate change is likely to affect agriculture, creating risk of hunger, and water resource scarcity with enhanced climate variability and more rapid melting of Asian glaciers in the Region (Cruz et al. 2007, 483). Recent studies in 2008 have shown that the annual precipitation for the Mekong Basin as a whole by 2030 will increase by

[39] Department of Energy Promotion and Development (EPD), http://www.poweringprogress.org/).

13.5 percent from the historical average of 1,509 mm to 1,712 mm (see Cruz et al. 2007; Lao PDR 2010, 12; SEA START[40]). SEA START has also projected that the length of the dry season will be longer in the future.

The International Center for Tropical Agriculture (Lefroy et al. 2010) study states that during the 20th century, the minimum, mean, and maximum temperatures increased throughout Laos, but particularly in the south and mainly in the last decade of the century. Total rainfall tended to increase by up to 115mm in the lower north and upper central part of the country, and decrease by up to 200mm in the upper north, lower central, and south of the country in Lao PDR. There is evidence that the number and intensity of storm events has increased in the last few decades of the 20th century, and this trend appears likely to continue and increase in the future. (Lefroy et al. 2010, v, vi)

Long-term and reliable climate records do not exist in Laos and there is limited assessment, analysis or projections regarding the potential climate change impacts on the physical and social environment in Laos. However, existing current global and regional analyses and assessments/prognoses support the fact that, as a whole, mean annual temperature will increase, dry season will last longer, droughts will be more severe and frequent, and floods will be worse and more regular causing extensive damage to property, productive assets, human life, and livelihood in Laos. (ADB 2010, 20; 2007; GEF et al. 2009, 57, 58; K. Pholsena, personal communication, 2010; Lao PDR 2010, 6; 2009, 12, 13; Lefroy et al. 2010, vi, 1; WB 2012, 16; WREA et al. 2008). Extreme events are predicted to cause agricultural and infrastructure losses, food security, and lives. They will also have adverse effects on forestry, water resources and health. It has also been projected that climate change will cause land degradation and soil erosion from increased precipitation and a higher prevalence of infectious diseases. (Komany 2012; Lao PDR 2009; MRC 2009, 3; World Bank's Climate Change Knowledge Portal 2014). The fact that the majority of Laos' population lives in the most disaster-prone areas have exacerbated disaster risks (EcoLao 2012, 5, 6).

Institutional Arrangements for Climate Change Management at National Level and for Water Resources

The Ministry of Natural Resources and Environment (MoNRE) houses the Department of Environment, which hosts the former Climate Change Office (founded in 2008), nowadays Department of National Disaster Management and Climate Change which acts as the Designated National Authority or as a national focal point for the UNFCCC (The REDD desk[41] 2014). The aim of the Department is to coordinate the development of both a national strategy to manage climate change and its impacts, and an action plan that details substantive climate change leadership, action, and programmes for Laos. The MoNRE has been empowered to coordinate all climate change matters and is responsible for the management, monitoring, and assessment of natural resource use and the contribution they make towards poverty reduction and economic growth in the country. (EcoLao 2011, 14, 16).

[40] http://www.start.or.th/

[41] http://theredddesk.org/countries/actors/ministry-natural-resources-and-environment-lao-pdr

Department of Water Resources (DWR) at MoNRE is responsible for the planning, development, management, and protection of the national water resources (surface and ground waters), as well as measuring the quality and quantity of the water resources. DWR is also responsible for the effects of climate change on water resources, and the management of the integrated river basin, including the management of floods and periods of drought. In 2008, the National Steering Committee on Climate Change (NSCCC), responsible for the national climate change strategy, was established. The Committee is responsible for the development and implementation of policies, plans and measures to address climate change issues at the national level. Eight Technical Working Groups were also established to assess the impacts and outline priority actions for adaptation and mitigation. The Government also revised the mandate of the National Environment Committee, to include climate change in its duties and responsibilities in 2009. (GFDRR & CIF 2011; Lao PDR 2010, 7; Lefroy et al. 2010; Lian & Bullar 2007, 11; MoNRE 2012, 10; The REDD desk 2014).

The Government has paid special attention to climate change impacts and mainstreamed climate change factors into overall sustainable development as well as into sectoral plans including the water sector. All sectors have adaptation strategies, and all except the water resources and public health have mitigation strategies (MoNRE 2013, 24, 26). The Government of Laos has signed the United Nations Framework Convention on Climate Change (UNFCCC) in 1995 and the Kyoto Protocol in 2003 (Lao PDR 2009, 2). A number of non-state actors connected to climate change have been founded in the country, and in politics operational strategies and plans have been prepared such as Strategy on Climate Change of the Lao PDR, and National Adaptation Programme of Action to Climate Change (NAPA) (GFDRR & CIF 2011; Lao PDR 2009; 2010, 7; Lefroy et al. 2010). The purpose of the National Climate Change Strategy is to outline GoL's approach to mainstreaming climate change in the 7th National Socio-economic Development Plan, building climate resilience in critical sectors in relation to economic development and poverty reduction. The Government of Laos is also pursuing a policy of working in partnership with international organizations and other states to develop capacities in this regard. (MoNRE 2012, 11, 93).

The main objective of the NAPA is to develop a country driven program to address immediate and urgent needs related to current and projected adverse effects of climate change in key sectors, namely, agriculture, forestry, water resources and public health. In this regard, 45 priority projects have been identified to implement urgent plans in adaptation to climate change. (Lao PDR 2009, 1, 8, 40). NAPA identifies eight themes: (i) building climate change awareness, (ii) strengthening policies and institutional capacity, (iii) mainstreaming climate change, (iv) expanding the knowledge base, (v) building the adaptive capacity of the poor, (vi) enhancing ecosystem resilience, (vii) comprehensive disaster management, and (viii) climate change mitigation (ADB 2011, 50). The NAPA brings up cross-sectoral questions and issues which are linked to national development plans and strategies concerning all sectors (see. e.g. GFDRR & CIF 2011; MRC 2009, 26).

Responding to Climate Change: Adaptation Measures in the Water Sector

Operational changes and changes in the infrastructure as well as developing demand management, water politics and regulations provide possible adaptation alternatives for water management (Brekke et al. 2009, 29; MLTM et al. 2012, 8). Developing and improving the institutional set-up of water management can facilitate resilience to climate change (MLTM et al. 2012, 12). *Water management* can be generally defined as a set of activities including planning, assessment, regulation, operation, monitoring, conflict resolution, and communication with an aim to balance the diverse uses, users, functions, and values related to water (Dukhovny et al. 2008, 19; GWP 2000; UNESCO-WWAP 2003 in Jusi, 2013, 64). The concept of *adaptation* has been defined in several ways. Adgera et al (2005, 78) has defined it "as an adjustment in ecological, social or economic systems in response to observed or expected changes in climatic stimuli and their effects and impacts in order to alleviate adverse impacts of change or take advantage of new opportunities" (see also Pielke 1988, 161; UNFCCC 2007, 10).

In the water sector adapting and adjusting to the new conditions caused by climate change such as extreme weather events (floods and drought) requires planning and interventions, and development of the institutional sector. IPCC (Bates et al. 2008, 65, 66) has described approaches, which can be used in the planning for adapting to climate change in the water sector during unpredictable hydrological conditions. These approaches include scenario based planning, adaptive management and *integrated water resource management*, the last of which has specially gained ground in Laos. Global Water Partnership (GWP 2000, 22) has defined IWRM "as a process that promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems". IWRM can be used to address climate change adaptation planning in the light of uncertainty in the future hydrological conditions (Pahl-Wostl et al., n.d in Nicol & Kaur 2009, 5).

The Lao water sector has in the past few years undergone reforms based largely on IWRM. The country has revised legislation, strategies and regulations connected to the water sector, and modernized its water organization. The country has incorporated IWRM principles into national development agendas and developed IWRM-based national strategies and plans, water law, and legislation. (see Jusi 2013). One adaptation measure/intervention applied in Laos to increase the irrigation system's capacity to respond to climate change is improving the existing irrigation schemes (efficiency) by implementing Government's policy on irrigation management transfer (IMT), where the operation and maintenance of irrigation schemes are transferred from the government to the farmers (see Jusi and Virtanen 2005). The country is also developing River Basin Committees (RBCs) which aim to establish and consolidate IWRM at the river basin level (see AMRC 2007; Bandaragoda 2006). These developments in Laos are in line with the fact that polycentric governance systems are more adaptive than centralised and fragmented systems with regards to climate change adaptation (Pahl-Wostl et al. 2012). However, there are still several constraints and difficulties of institutionalizing the approach at different levels from regional to local level in Laos (see Jusi 2013).

In NAPA several priority activities have been addressed (priority one, most urgent and priority two, less urgent groups) for climate change adaptation in water sector (Lao PDR 2009, 43). Priority one activities are: (1) awareness raising on water and water resource management, (2) mapping of flood-prone areas, (3) establish an early warning system for flood prone areas, and improve and expand meteorology and hydrology networks and weather monitoring systems, (4) strengthen institutional and human resource capacities related to water and water resource management, (5) survey underground water sources in drought prone areas, (6) study, design and build multi-use reservoirs in drought prone areas. Priority two activities are (7) conservation and development of major watersheds, (8) build and improve flood protection barriers to protect existing irrigation systems, (9) improve and protect navigation channels and navigation signs and (10) repair/rehabilitate infrastructure and utilities damaged by floods in agricultural areas. (Lao PDR 2009, 43, 49–54). In the NAPA there is however no statements related to water quality and water ecosystems (WEPA 2012, 47).

In the Strategy on Climate Change of the Lao PDR (2010, 12) there are several adaptation options identified related to water resources. These are:

1) Assessing the hydropower industry's vulnerability to climate change effects;
2) Developing climate change scenarios for the river basins, which can be used to simulate future river flows, using hydrological models adjusted to reflect the results of the global and regional climate models; impacts of climate change on river bank erosion, hydropower structures and production can thus be projected and adaptation strategies formulated;
3) Developing reliable early warning systems to reduce disaster impacts through floods and drought risk management;
4) Downscaling climate and hydrological models to a watershed level; ensuring greater access to climate and hydrological data;
5) Integrating climate change measures into current risk management strategies and planning processes;
6) Planning and design criteria for hydropower structures need to be robust to withstand changes in climate; designing hydropower dams and reservoirs so as to accommodate the potential changes in water levels as a result of climate change. (Lao PDR 2010, 12)

From these two plan of operation it can be seen that the focus and the aim of adaptation measures and strategies is on pretty much on building adaptive capacity and declining vulnerability and climate-induced hazards in the water sector in Laos. Adaptation and mitigation actions and alternatives should be assessed together and parallel with many 'water linked' sectors, because water management affects several other policy areas such as food security, environmental protection, energy and health (Bates et al. 2008, 4).

Challenges

Climate change is one challenge among many in water management and therefore a holistic approach, which takes into consideration all significant drivers of change, has to be considered in water resource management (see Brekke et al. 2009). Laos is very susceptible to the impacts of climate change as the adaptive capacity of the country is very weak and in the future risks accumulate faster because capacity building is slow. In the future if the development of capacity is slow, it will increasingly expose the country to risks inherent in climate change. Therefore it is very important to assess the weaknesses and adaption strategies of the sectors such as the water sector which are susceptible to climate change in order to develop sectoral strategies to overcome risks (MoNRE 2012, 50; WB 2012, 16). In addition, there is a need to strengthen co-ordination and co-operation between different sectors and organisations (Lao PDR 2009, 40; Oudomdeeth 2010; Sengkhammy 2012).

On the whole, Laos as many other developing countries has big adaptation challenges related to capacity in the water sector. The country is facing big challenges related to financial, human, and technical resources creating capacity constraints in the water sector (Jusi 2013, 129). Especially at the provincial, district and local levels the country's capacity to prepare and develop adaptation strategies is very weak. Adaptation planning should be based on the assessment of the current and future changes and vulnerability due to climate change. These assessments in turn should be based on scientific knowledge the availability of which is scarce in Laos. (EcoLao 2012, 1; Schipper et al. 2010, vii).

In general, scientific knowledge and thorough research on the impacts of climate change, adaptation and mitigation strategies is still very scarce in Laos and there are very few national adaptation specialists. Public awareness on climate change issues is at a low level among government agencies, academic institutions, communities in risk prone areas, and the general public in Laos. (Lao PDR 2009, 40; Oudomdeeth 2010; Sengkhammy 2012). "A key knowledge deficiency is that despite of theoretical training courses, they have not been followed up with practical applications, particularly with regard to water resource management methodology" (EcoLao 2012, 1). Laotian government agencies should partner with regional or international institutions with significant climate and adaptation specific expertise to bridge the knowledge gap related to practical application (Ibid, 17). The former WREA, current MoNRE aims to work closely together with National University of Laos (NUOL) to build capacity to undertake research, especially applied research related to water resources management and climate change issues (Pholsena, personal communication, 2010).

There are still big gaps and shortages in financing in relation to implementing adaptation actions (Lao PDR 2009, 40; Oudomdeeth 2010; Sengkhammy 2012). As Lian and Bullar (2011, 89) states, many of the ASEAN countries including Laos rely on external assistance, which raises concerns about the long-term sustainability of these adaptation actions. This is particularly relevant in the case of climate change adaptation where the adverse impacts may only manifest themselves in the long-term.

Key Findings and Conclusions

International meetings and conferences often focus on climate change issues, but water and water related questions are not seen as equally important with questions of carbon dioxide emissions, weather extremes, and risks and scenarios of change despite the fact that water resource management plays an essential role in adapting to climate change (Bates et al. 2008; MLTM et al. 2012, 38). Therefore, the role of water resource management and planning should be emphasized in adaption to climate change. In addition, planning should be better informed and more inclusive (Nicol & Kaur 2009, 7).

It is predicted that climate change will increase temperatures also in Laos, periods of drought and floods will become more frequent and their intensity will grow causing serious problems to Laos and its people. It has been additionally predicted that precipitation and the flow in the Mekong River will increase which together have a significant impact on water resource management. The accelerated use of Lao water resources in different sectors e.g. hydropower, industry, mining, agriculture, tourism, fisheries, and transport will increase competition about water and its scarcity. This development also impacts, and will increasingly do so in the future, the quality of water, environment and human health. These changes together with climate change and the increasing complexity of the water sector make it necessary to see the water resources in a larger development context, which means replacing the sectoral approaches by more holistic and integrated methods to manage water resources (IWRM) in Laos and the entire Mekong river region (Jusi 2013).

Laos still has many weaknesses in its struggle against climate change. The greatest of them are lack of human, technical and financial resources, adequate scientific knowledge and experience of climate change management. In addition, there is a need to study the vulnerability of the water sector, develop coping mechanisms and methods as well as short- and long-term adaptation strategies to face climate change and its impacts. Their development should be based on scientific knowledge, which necessitates scientific research on climate change. Also, practice and local level based and experimental knowledge of water managers and users and jointed up approaches (from household, village, kumban and district levels) are important for finding practical solutions and responses. Laos can also learn from the strategies of water management and climate change at different levels (national, sectoral, local) in other countries.

It is important to remember that the challenges of the water sector are always systemic in nature and inseparably linked to the greater economic, social and political questions of water management (UNESCO-WWAP 2003, 370). Pressures for change faced by the water sector come often from outside and therefore holistic and sustainable management of the water resources as well as good governance are important. Integration of climate change into the broader context of environmental and social change and into socio-economic policies, development plans and programmes is being encouraged (Keskinen et al. 2010; Lian & Bhullar 2011, 87; OECD 2009). "There is a clear need to integrate climate change mitigation, adaptation and disaster risk reduction into the agenda of water and land management at all levels" (Bach et al. 2011, 18). Also, ICEM (2013) report on Mekong climate change impacts emphasises the importance of integrated adaptation. Integrating policies, structures and procedures, spatial planning as the base for adaptation at the site level is accentuated (ICEM 2013, 235–236). In terms of holistic approach methods, instead of examining only climate change, the need for Cumulative Impact Assessment (CIA) to fully understand the intertwined impacts related to changes impacting environment and different water use sectors at multiple spatial scales has emphasized (EcoLao 2012, 18; Kummu 2008 in Keskinen et al. 2010, 112).

Due to governance of the country which is very centralized and works from up to down leaving the local and horizontal governing systems weak the question can be raised whether the local level has been, and is being involved enough in deciding on the policies concerning the adaptation and mitigation methods and climate change (Jusi 2013). To confront the additional stress induced by climate change, public participation in water planning will be necessary (Bates et al. 2008, 95). It is the local level where the actual impacts of climate change become reality often affecting the poorest people, who depend on traditional forms of farming and land (MAF 2010). In this context the importance of strengthening the capacity of the local people cannot be too much emphasized in order for them to participate in decision making and planning, and to improve the possibility of contributing to decision making in general. The GoL' policy of IMT, where the management of irrigation schemes is transferred from the Government to local water user groups to improve efficiency and system performance of the schemes is an example of a policy that aims to address the issue of participation to decision-making and social access and reducing risk from climate change. Also creating River Basin Organisations as an adaptive governance arrangement is a means to enhance local level water planning, decision-making, management of reservoir operation regimes and participation and to dealing with the climate change at the basin level in Laos.

The creation and implementation of the adaptation and mitigation strategies to climate change as well as the implementation of IWRM policies need to take into consideration the local context and its special features, resources and obstacles (see also Lian & Bullar 2011). Scientific research in the area of water resources adaptation measures to climate change which would tackle deeper the problems connected with participation and empowerment of the people at local level.is highly needed (see also Bates et al. 2008, 28).

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Using Scenarios for Information Integration and Science-Policy Facilitation: Case from the Tonle Sap Lake, Cambodia

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The interconnections between water, food, energy and climate in Cambodia's unique Tonle Sap area were looked at in a two-year interdisciplinary research project. Several research methods were applied in the project, ranging from hydrological modelling to socio-economic database analysis and household surveys. These more traditional research methods were then complemented with the application of scenario approaches that made use of scenario narratives, scenario workshops and, ultimately, alternative scenario formulation. As a result, the main research results were synthesised – and, importantly, communicated and discussed – through four alternative scenarios created for the Tonle Sap in 2040, indicating radically different but nevertheless plausible futures for the area. While the hydrological and livelihood analyses created the basis for the understanding of key drivers in the area, the scenario process facilitated integration of diverse, discipline-specific information. In addition, the possibility to discuss alternative storylines allowed better consideration of the uncertainty and complexity included into the analyses.

Introduction and Background

The Tonle Sap Lake and its floodplains form vital resource for the entire Cambodia. Unique flood pulse system and huge fish productivity have been driving the development of the surrounding societies at least since the Angkorian era in 9th Century. Today, the lake-floodplain system is a global biodiversity hotspot that supports remarkable production of fish, rice and other agricultural and wetland products. The Tonle Sap forms the basis for the food security and livelihoods for millions of Cambodians (e.g. Keskinen et al. 2013; MRCS/WUP-FIN 2007; MRC 2010; Mak et al. 2012).

People living in and around the Tonle Sap Lake have adapted to the enormous annual variation of the lake's water level: many even live in floating houses on the lake itself. People's livelihoods are closely connected to the lake and natural resources it enables and supports. While agriculture remains the main source of livelihood, the role of fishing and related activities is remarkable as well. The urban centers around the lake have rather different livelihood structures, with growing involvement in trade, service sector, tourism, construction, and industrial activities. At the same time, the livelihood structure of the Tonle Sap area is diversifying, with increasing amount of people transferring from traditional, agriculture-based livelihoods to more modern sources of income, and the provincial capitals – Siem Reap in particular – attracting migrants from the rural areas (Keskinen et al. 2013).

The Tonle Sap Lake is closely connected to the mighty Mekong River, making the management of the Tonle Sap also a transboundary issue. The annual floods of the Mekong are the main driving force for the Tonle Sap flood pulse, extending the lake to the vast floodplains and bringing fertile suspended solids as well as fish larvae to the lake-floodplain system. Without the Mekong, the Tonle Sap would not be as productive and unique as it is today. For the same reason, the environmental changes happening in the Mekong River Basin have direct impacts to the Tonle Sap system and the lake system is considered to be the most vulnerable for the planned large-scale hydropower development in the Mekong Basin. (e.g. Lamberts & Koponen 2008; Kummu & Sarkkula 2008; Keskinen et al. 2013; Arias et al. 2014; Kummu et al. 2014)

This article presents the main methods and findings of the so-called 'Exploring Tonle Sap Futures' research project (http://www.wdrg.fi/research/exploring-tonle-sap-futures), building on the Final Report of the project (Keskinen et al. 2013). The project was part of the regional 'Exploring Mekong Region Futures' programme (http://www.csiro.au/science/MekongFutures). It sought to increase the understanding of the future development of the Tonle Sap area through in-depth analysis of hydrology and livelihoods. These two research components were then supplemented by scenario formulation process. This article described the main methods and key findings of this research project, with the discussion focusing on the usefulness of the scenario approach in synthesising and communicating the findings from the more traditional research.

Material and Methods

A central part of the Exploring Tonle Sap Futures project were two research components focusing on water as well as on demography and livelihoods (Keskinen et al. 2011, 2013). The research component on water ('Hydrological analysis') analysed the possible impacts of regional changes – focusing on Mekong hydropower development and climate change – to the Tonle Sap system and its exceptional flood pulse (Lauri et al. 2012). The analysis was carried out with the help of two mathematical models. A hydrological model called VMod was established for the whole Mekong basin, and it was used to simulate the cumulative impacts of development and climate change on the Mekong flow regime. The VMod model was then linked to a more detailed EIA 3D floodplain model that simulated the impacts of basin-wide cumulative changes on the Tonle Sap flood pulse. The regional climate change scenarios for the hydrological model were obtained by downscaling five different global climate change models (GCMs) for the Mekong Basin, while the MRC hydropower database was used to estimate the future development in the large-scale hydropower construction in the Mekong Basin (Keskinen et al. 2011; Lauri et al 2012).

The research component on demography and livelihoods analysed then current demographic, social and economic setting and trends in the Tonle Sap area. The livelihood analysis built on extensive 'spatio-statistical' analysis[42] of the key socio-economic databases (Population Census 1998 and 2008), and it was complemented by the CSIRO Tonle Sap Household Survey that included 1000 household interviews in 50 villages in the area (Ward & Poutsma 2013; Salmivaara et al. submitted). Due to Cambodia's tumultuous history, the Population Censuses of 1998 and 2008 are the first ones since 1960s and they thus provide a major opportunity to look at the demographic and socio-economic trends at the village level. Yet, there has to our knowledge been very few analyses done on such trends anywhere in Cambodia, and none in the specific context of the Tonle Sap.

The two research components were then supported by a scenario process that included three phases. The process was initiated by the creation of alternative of scenario narratives for the Tonle Sap, produced during the first two stakeholder workshops (Foran et al. 2011). These scenario narratives helped then to focus the actual

[42] The term 'spatio-statistical approach' indicates that the available quantitative data is analysed with spatial approach, and that the robustness of the approach has been tested statistically.

research that was discussed in the following workshops. The workshops were organised by the governmental Tonle Sap Authority (TSA) in collaboration with Supreme National Economic Council, CSIRO and Aalto University, and they were participated by number of experts from different line agencies and organisations. Finally, the research findings were then put synthesised through the creation of four alternative scenarios for the Tonle Sap in 2040 (Keskinen et al. 2013).

Results

This section presents the selected key findings from the hydrological and demographic & livelihood analysis: for more detailed results, please see Keskinen et al. (2013), Lauri et al. (2012) and Salmivaara et al. (Submitted).

Hydrological analysis[43]

The impact from the Mekong hydropower development and climate change was analysed in our study both separately and together, using a ten-year timeframe until the year 2042. This is to our knowledge the first time that the cumulative impacts of hydropower development and climate change on the Tonle Sap flood pulse have been assessed at this level of detail.

The results indicate clearly that the flood pulse of the Tonle Sap is likely to change in the future, with the planned hydropower dam development in the Mekong River Basin causing dramatic changes on the flood dynamics. The hydropower operation will flatten the hydrograph by causing higher dry season water levels and lower flood peaks. Climate change, on the other hand, is expected to cause changes to the rainfall and temperature in the area (Lauri et al. 2012), impacting the runoff and water levels in the Mekong mainstream and, thus, in the Tonle Sap system. Yet, our analysis indicates that the exact impact of climate change remains unclear, mainly due to differences in the different GCMs applied to the Mekong Region and whole monsoon Asia (e.g. Ashfaq et al. 2009). Even the direction of the change caused by climate change differs depending on the emission scenario and GCMs used. Consequently, it is impossible to say even whether climate change will increase or decrease the flood season water level or flood volume (Lauri et al. 2012).

Within the timeframe used in our study (i.e. by year 2042), climate change alone does not have a considerable impact on the dry season water level in the lake. In addition, even the direction of climate change impact on the Tonle Sap flood peak is unclear. The climate change impact on the flooded area (that is an important factor for ecosystem productivity) is thus very uncertain, with the estimates for the future floodplain area varying from 92% (8'832 km^2) to 109% (10'464 km^2) of the current average floodplain area of 9,600 km^2.

In contrast, the cumulative impacts of hydropower operation and climate change have a clear impact on dry season water levels, which are estimated to be 0.5–0.9 m above the current levels. This would mean that the permanent lake area would increase 18–31%, submerging important habitats of, for example, flooded forest (Figure 1). For the flood season water levels the cumulative impacts are significant, with modelling estimates indicating lower flood peaks, although with large uncertainty due to the differences in GCMs used in the study. The flood-

[43] This chapter is based on the following two main sources: Lauri et al. 2012 & Keskinen et al. 2013.

plain area can reduce significantly due to cumulative impacts from climate change and hydropower reservoirs, with minimum area being around 75% of the current floodplain area.

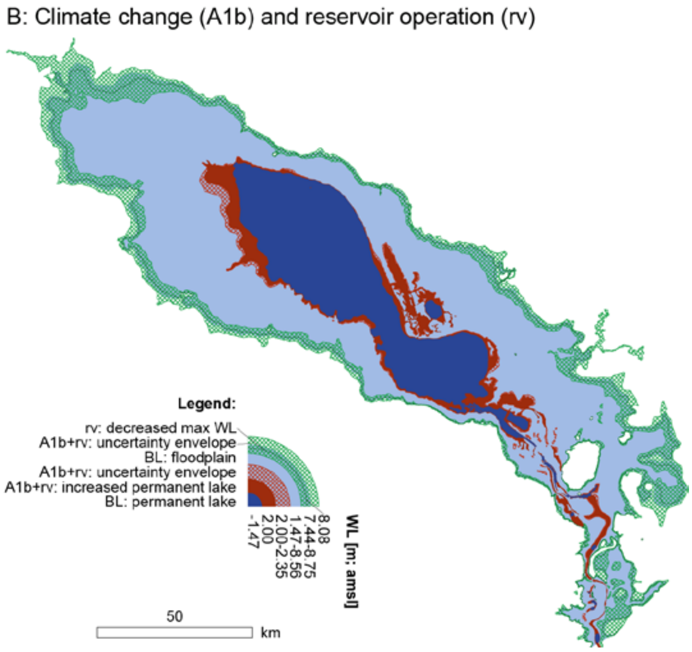

Figure 1. Map of the estimated future changes (2032-2042) caused by the cumulative impacts of climate change (A1b) and reservoir operation (rv) in the permanent lake and flooded areas compared to the baseline (BL; 1982–1992). Source: Keskinen et al. 2013.

Demographic and livelihood analysis[44]

The Tonle Sap area as defined in this research[45] includes 1555 villages, and the analysis of this extensive dataset therefore requires some classification. Based on the topographic zoning and the level of urbanisation and supported by statistical analysis, the Tonle Sap area was divided into three zones: Zone 1 (Lower Floodplain), Zone 2 (Upper Floodplain), and Zone 3 (Urban) that were further divided into 18 sub-zones based on the administrative boundaries of the six Tonle Sap provinces. The created three zones have very different relationships to the lake and its annual flood pulse, as the flood pulse impacts greatly on the floodplain functions and vegetation (Arias et al. 2013). It is also critical to note that the three zones differ greatly in terms of both population and area, with Zone 2 clearly having the biggest population and Zone 1 being the largest area-wise.

According to the data received from the Population Census 2008, there were 1'707'000 people living in the Tonle Sap. A great majority (1244) of the Tonle Sap villages are rural. Demographically remarkable is the dominance of the youth: as of today, the two biggest age groups are between 15–19 years and 20–24 years. This 'youth surge' is thus just entering the work force throughout the Tonle Sap, searching for meaningful work opportunities

[44] This chapter is based on the following two main sources: Salmivaara et al. Submitted & Keskinen et al. 2013.

[45] The Tonle Sap area was in this research defined to be the area between National Roads 5 and 6, with a 3-kilometer buffer beyond the roads .The area doesn't include the Tonle Sap River, as the area is separated from the river with a line located east from Kampong Chhnang and Kampong Thom (Keskinen et al. 2013).

and changing dependency ratio (Figure 2). The Tonle Sap area is – similarly to entire Cambodia– thus seeing a possibility for the so-called demographic dividend, where a rising proportion of working age people and, consequently, decreasing dependency ratio, can lead to increased development and economic growth (Bloom et al. 2003; Keskinen 2008). This requires, however, a development context that provides meaningful possibilities for employment: otherwise the increase in work force can also lead to accelerating environmental and social problems when more people compete for the same limited natural resources.

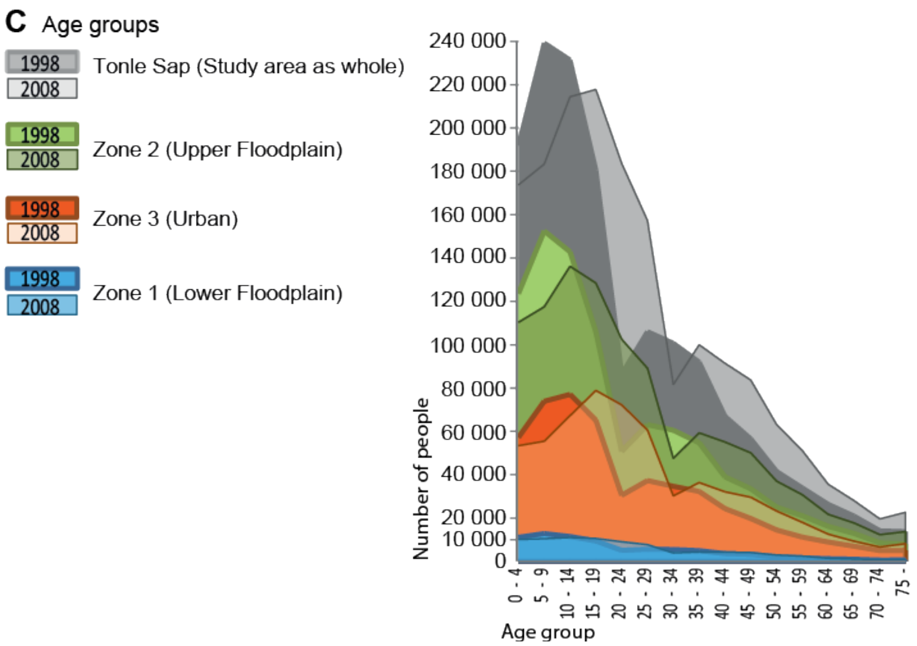

Figure 2. Age profiles according to five-year age groups for the entire Tonle Sap area as well as for each of the three zones separately, showing very clearly the so-called youth surge. Source: Salmivaara et al. Submitted.

Overall, the Tonle Sap area is changing both socially and economically, but the pace varies notably across the area. The main livelihood sector in the area is very clearly agriculture, with 61% of total work force having it as main livelihood. Trade comes second (11.5%) and fishing third (4.5%). The CSIRO Tonle Sap Household Survey (Ward & Poutsma 2013) indicates similar figures, although the proportions of trade (around 20%) and fishing (5.8%) are higher than in Census. Together, agriculture and fishing are the major contributors for national food security.

While the proportion of workforce engaged in the 'Agricultural, hunting and forestry' sector (great majority of which is agriculture) decreased from 66% in 1998 to 61% in 2008 the amount of workforce in the sector increased remarkably, i.e. by 130,000 people, due to population growth. This naturally indicates an additional pressure on agricultural land and related resources. Similar finding was evident in fishing sector, where the proportion of people involved in the sector has decreased slightly (from 4.7% in 1998 to 4.5% in 2008), but due to population growth the absolute number of people having fishing as the main economic activity increased by 10,700 between 1998 and 2008.

While the agriculture, trade and fishing keep on dominating the livelihood portfolio in the Tonle Sap, there are signs for increasing livelihood diversification as well. The most rapidly growing livelihood sector in the Tonle Sap between 1998 and 2008 was construction that increased from 1% in 1998 to 4% in 2008. Other increasing (although still minor) livelihood sectors include manufacturing, hotels and restaurants, other service activities, and real estate, renting and business activities.

Alternative scenarios created for the Tonle Sap in 2040[46]

The findings presented in the two chapters above provide differing views for water- and livelihood-related future changes in the Tonle Sap. The findings also include major uncertainties and unknowns on, for example, the impacts of climate change as well as on key aspects related to social and economic development and their linkages to environment and natural resources. Socio-economic development is after all never linear, and any trend analysis of past socio-economic data is therefore unlikely to hold true for the future.

For these reasons, we felt that it doesn't make sense to generate just one possible view – or best guess – about the ways the hydrology, demographic and livelihoods are likely to develop in the future. Instead, we decided synthesise our research by creating four alternative scenarios (or alternative futures) for the Tonle Sap in 2040. The four alternative scenarios build on the possible changes and trends that water and livelihoods will bring to the area, but they were also influenced by the future-oriented scenario narratives that were created during the first two stakeholder workshops (Foran et al. 2011. The key research findings presented above influenced therefore greatly to the way the four alternative scenarios were formed: they essentially formed the frames within which we allowed us to create the alternative futures.

In this way our alternative scenarios – while making use of scenario techniques – can be seen to be close to data- and analysis-based forecasts. In other words, they build on our modelling estimates and trend analyses and don't generally include major surprises or irregularities. There are also other, more innovative and less rigid ways to create scenarios: see e.g. Schwartz (1996), van Notten (2006), Foran et al. (2011), Heikinheimo (2011), Smajgl et al. (2011) and Zhu et al (2011). Despite this, we still feel that the following scenario description by IPCC (2012) captures well the main characteristics of our four alternative futures as well: *"A scenario is a coherent, internally consistent and plausible description of a possible future state of the world. It is not a forecast; rather, each scenario is one alternative image of how the future can unfold."*

The starting point for the scenario formulation for the Tonle Sap was the decision to build (or not) more mainstream and tributary dams in the Mekong upstream. This decision created then two alternative 'water paths' – and the related 'energy paths' – for the scenario process: one with plenty of Mekong dams (blue path) and one with only Mekong dams currently existing or under construction (green path). Following, the differences in the socio-economic and livelihood development by 2040 led to two different kinds of 'societal development paths': one good and one not-so-good. The 'societal development paths' build on our analysis of socio-economic and livelihoods trends, but they are also very closely linked with key government strategies for the development of the Tonle Sap (RCG 2001, 2010).

Together, two 'water paths' and two 'societal development paths' create then four alternative scenarios for the Tonle Sap by 2040: A) Major changes, B) Growing disparity, C) Green growth, and D) Stagnation (Figure 3). In

[46] This chapter is based on Keskinen et al. 2013.

the Final Report of the research project (Keskinen et al. 2013), each of this alternative scenarios were then described in more detailed level, including the policy implications included in each of them. The Final Report also includes description of three 'surprise factors' – or wild cards – that could influence remarkably the development in the area. Such surprise factors were drawn from the discussions emerging during the stakeholder workshops and included intensive oil and gas extraction in the Tonle Sap; Tonle Sap algae for renewable energy; and Tonle Sap as Southeast Asia's prime ecotourism destination (Keskinen et al. 2013).

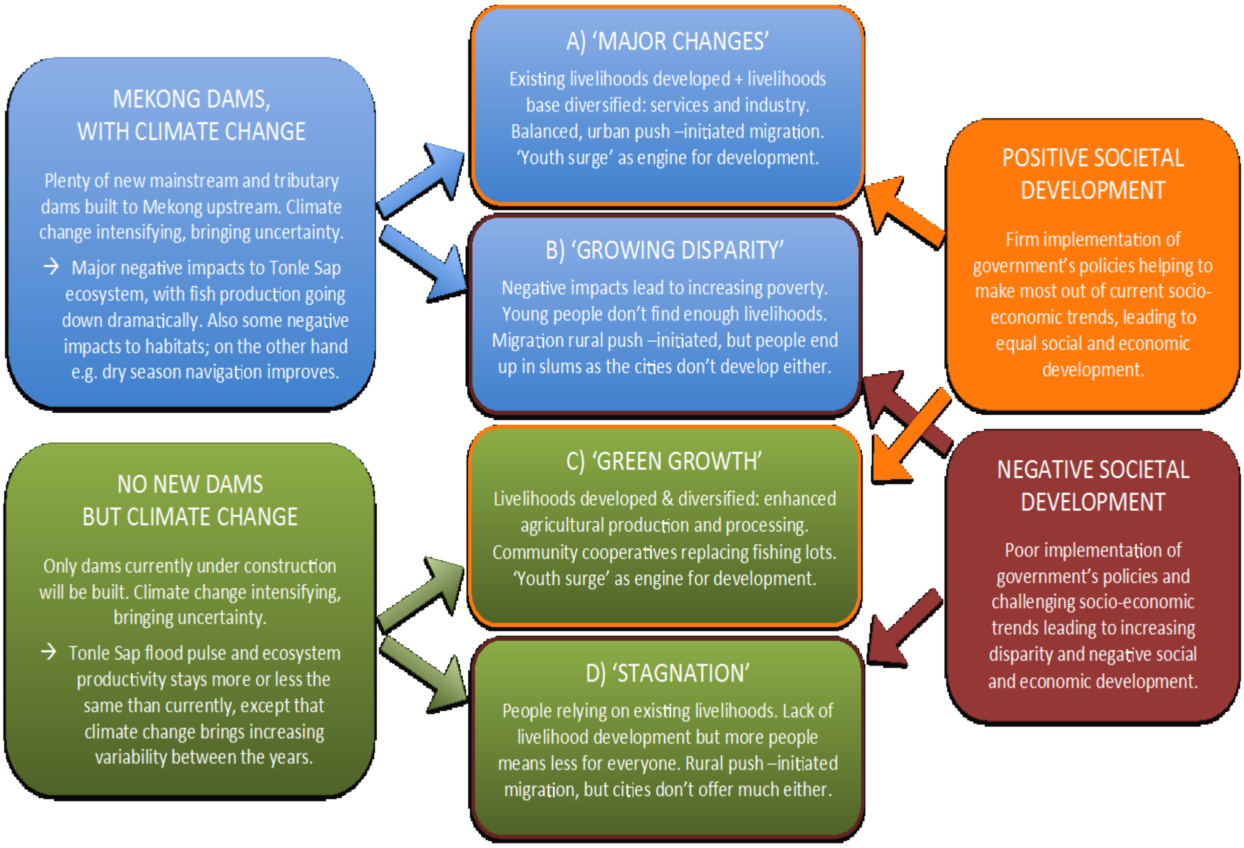

Figure 3.Visualisation and brief description of the four alternative scenarios created for the Tonle Sap in 2040: for explanations, see text. Source: Keskinen et al. 2013.

The scenario process also means that each alternative scenario is similar to two other alternative futures: they either share same 'water path' or have similar 'societal development path'. In this way our alternative scenarios differ from conventional scenarios that seek to be more clearly different from each other. Yet, we do believe that our four alternative futures do capture the trajectories that potentially follow from the transformations we expect to happen in the area due to: a) changes in water flows due to water resources development in the Mekong River Basin and/or climate change, and b) current demographic and socio-economic – and the related policies – in the Tonle Sap area. In this way, we feel that all four alternative futures represent possible and, in terms of policy implementation, realisable scenarios for the Tonle Sap area by 2040 (Mahmoud et al. 2012).

Discussion

Using scenarios for information integration and science-policy facilitation

This article first presented the overall context of the Tonle Sap are in Cambodia, and then proceeded to present the key research findings from our recent research project focusing on hydrological as well as demographic and livelihood analyses. Finally, we introduced the four alternative scenarios that were created for the Tonle Sap, with two specific aims: 1) to integrate the diverse information related to water resources, the environment and people, and 2) facilitating science-policy interaction by providing a novel platform for discussion about the Tonle Sap's future.

Overall, the four alternative scenarios created for the Tonle Sap in 2040 provide a perspective on the possible future paths that the Tonle Sap area may experience, building on the hydrological as well as demographic and livelihood analyses carried out as part of the research project. While the basic setting depends on external driving forces such as Mekong hydropower development, the scenarios also indicate that the future development of the Tonle Sap depends very much on the way the area's socio-economic setting and livelihoods are evolving. In this, the policies and governance structure applied by the Cambodia's central government and provincial and district authorities assume a primary role.

Our experience indicates that scenarios facilitate integration of diverse, discipline-specific information, particularly through creation of comprehensive future storylines/scenarios that combine information from different sources and analyses. Possibility to discuss several alternative storylines allows also better consideration of the uncertainty and complexity related to water and its management. We also see that scenarios provide a powerful way to take the views of different stakeholders into account when planning and implementing research as well as when presenting research findings. This way the scenarios also helped to strengthen science-policy-practice linkage. Scenarios also allowed us to look at and discuss decision-making processes and policies, which is in many settings not that easily done for example for political reasons.

At the same time our experience reminds us that scenarios need to be used with caution, as due to the comprehensiveness and complexity included in the scenario formulation, they can easily become rather subjective. Scenarios are thus easily guided – intentionally or not – with certain perceptions and mental models, emphasising the need for careful facilitation. Even then, scenarios should be considered more as subjective interpretations created (and to be used) in a specific context, rather than as general conclusions from a research project.

Water-energy-food-climate nexus

The findings from our study indicate that the social and economic development of the Tonle Sap has close linkages to land and natural resources and, more broadly, to the so-called water-energy-food nexus – or in our case water-energy-food-climate nexus. Water is also in many ways the connecting factor between these different themes. The connections are being characterised by a very interesting dualism: water simultaneously enables and is impacted by energy production and food production. The situation is similar in terms of climate change: water has close linkages with climate change mitigation as majority of the world's renewable energy production – dominated by hydropower and bioenergy – is directly linked with water (Varis 2007). At the same time, water also connects closely with climate change adaptation as majority of the climate change's impacts to societies – e.g. floods, droughts and extreme weather events – are felt through the changes occurring in hydrological cycle (e.g. Keskinen et al. 2010).

Worryingly, the energy and food production sectors seem not always to be considering the impacts they cause to water and the related resources. The water-energy-food-climate nexus also has a strong spatial dimension, as the decisions related to energy production are done at a very different level (i.e. Mekong-wide), compared to the level (i.e. Tonle Sap) where the food security- and livelihoods-related impacts caused by such decisions are occurring.

At the same time, water has close linkages with various different sectors, including for example agriculture, fishing, energy, and the environment, at both national and local levels. Consequently, it is obvious that the government's policies should not be implemented in isolation, but there must be active cross-sectoral collaboration between different agencies when implementing the relevant policies at the different levels in the Tonle Sap. The cross-sectoral collaboration should therefore build on integrated, holistic view on the development of the area, and is likely to require continuous discussions and deliberations as well as negotiated trade-offs between different ministries.

Conclusions

The Tonle Sap Lake area forms a critically important economic, social and environmental resource for entire Cambodia. The Tonle Sap flood pulse is the driving force of the entire lake-floodplain system – including its immense fisheries – and it also makes the area globally unique hydrologically, environmentally as well as socio-culturally. The Tonle Sap flood pulse is, however, likely to change in the future as a consequence of anthropogenic impacts, particularly through intensive hydropower development in the Mekong River Basin. We estimate that the possible changes in the flood pulse these changes are expected to radically reduce the ecosystem productivity of the lake-floodplain system, with a potential for the Tonle Sap fish production to go down by 50% or even more. Such a radical reduction would naturally present a major challenge for the Tonle Sap area and entire Cambodia, both in terms of livelihoods and food security.

At the same time the population in the Tonle Sap area keeps on growing. The Tonle Sap is – consistent with the rest of Cambodia – experiencing exceptionally large age groups of people born in the 1990s entering into the work force: we call this 'youth surge'. Given the dominance of agriculture and the already heavy pressure on the area's natural resources, the Tonle Sap's future depends very much on what kinds of livelihood sources these young people will, and are able to, move to. This has – luckily – also been noted by the development strategies of the Cambodian Government (RGC 2010). The livelihood structure of the Tonle Sap area remains to be dominated by agriculture, with over 60% of the total work force i.e. around one million people having agriculture as their main source of livelihood.

The future of the Tonle Sap area thus includes many uncertainties, and depends on both external driving forces – most importantly Mekong hydropower – as well as on internal changes in the socio-economic setting and livelihood structure of the area. Importantly, however, the Cambodian Government has possibilities to reduce the uncertainties and negative implications included in the future development of the Tonle Sap at regional, national and local levels. Overall, we see that the Tonle Sap development should particularly in rural areas build on existing livelihoods, with a focus on enhancing the agricultural productivity and improving the access to the markets.

In terms of methodologies used in the project, we found the scenario process to be useful in (at least) to different ways. First of all, it helped to link the results from our different research components more firmly together, hence helping the integration of variety of information integration. Secondly, the scenarios proved to be rather powerful in visualising the results and initiating the discussion about the possible future paths. In this way, they thus facilitated science-policy-practice linkages in a way that mere scientific analyses and their syntheses may not have been able to do.

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Synthesis of Top-Down and Bottom-Up Approaches for the Use of Early Warning Systems for Food Security: Case Studies in Malawi and Zambia

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Food insecurity is a pertinent concern in many Sub-Saharan countries. Exacerbating the situation, climate change is creating an additional burden due to projected increases in the risk of extreme hydro-meteorological events, thus deteriorating the food security situation and increasing the importance of effective Disaster Risk Reduction (DRR) and climate change adaptation (CCA). DRR is significantly improved by the use of early warning information (in particular seasonal outlooks for prolonged dry spells and short-range early warnings for floods) by key stakeholders. It also forms an integral part of CCA measures. Using policy analysis concepts, the purpose of this study is to assess the challenges in sharing and utilising early warning information for the purposes of DRR and CCA, and to propose actions to improve the current situation both from a top-down and bottom-up perspective. We find that on a grassroots level, DRR and CCA are tightly connected leading to the development of community-based EWS, but on a national level, the production and use of EWS requires substantial improvements.

Introduction

Background

Food security is defined as being influenced by four pillars: availability, access, utilisation and stability. All of them reflect the complex and multi-dimensional nature of food security. The main components behind food security relate to the physical, social and economic environments of individuals and communities (Stamoulis & Zezza, 2003; FAO, IFAD and WFP, 2013). Weather, climate variability and hazards, particularly droughts, pose a direct (through reduced yields) and indirect (through multiple links) stress on the situation, most notably in areas which have pre-dominant vulnerabilities to food insecurity, such as poverty, inefficient farming techniques, or political instability (Sen, 1981, Devereux, 2009). In Africa, this has been witnessed, for instance, in Ethiopia in 1999–2000, in Malawi in 2001–2002 and in Niger in 2004–2005 (Devereux, 2009). Southern African countries, in particular, 7 out of the 15 Southern African Development Community (SADC) countries are among the most food insecure countries (global ranking 90-109) in the world[47]. This situation is further expected to be exacerbated by climate change, as the impacts of changing temperatures and rainfall patterns are *very likely* to result in a decrease in yields of major cereal crops across Africa (IPCC, 2014). Furthermore, adaptive capacity, a combination of demographic and socio-economic factors, is low in most of the SADC countries.

Due to the expected, yet uncertain, negative impacts of climate change on food security, the development and use of measures to adapt to current and future impacts should be considered in a systematic and integrated manner, particularly in countries with low adaptive capacity. The common and distinct elements of Disaster Risk Reduction (DRR) and Climate Change Adaptation (CCA) should be emphasised (UNISDR, 2009; Gero et al., 2011; IPCC, 2012; Becker et al., 2013; Sperling and Szekely, 2005; Venton and La Trobe, 2008; Mercer, 2010; Shaw et

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[47] Global Food Security Index 2014; http://foodsecurityindex.eiu.com/

al., 2010). Some of the differences between DDR and CCA include: time horizon (relative emphasis on current and short-term trends vs. long-term change), mitigation approach (limiting adverse impact of particular hazard vs. limiting anthropogenic impact), and scope of risk management (whether mainly extreme weather events or diverse changes in climatic conditions). However, some argue that these differences are trivial and mainly conceptual for the purpose of policy design (Gero et al., 2011; Schipper and Pelling, 2006). The core messages conveyed by DRR and CCA convey are the continuous process of vulnerability reduction and capacity improvement, and the creation of sustainable and flexible long-term strategies that should lead to enhancement of local resilience (Sperling and Szekely, 2005; Schipper, 2009; Gero et al., 2011).

Robust, yet adaptive CCA strategies and measures are suggested as a means to tackle the impacts of climate change (Dessai and Hulme, 2007). Adaptive approaches encourage the possibility to adjust policies in the light of better information (Inghan et al., 2007) and to avoid sunk costs (Hallegatte, 2009). Hallegatte (2009) suggests the following approach: No regret measures which create benefits even in the absence of climate change; Reversible measures which are easily retro-fitted if climate change projections turn out to be wrong; Safety Margin measures which reduce the vulnerability of the system at a low or no-cost; Soft measures which can be institutional or financial; Reduced time horizon measures which involve reducing the lifetime of an investment; and strategies which have Synergies with mitigation. Early Warning Systems (EWS) are suggested as a No regret, reversible, and soft measure to respond to climate change impacts (Hallegatte, 2009).

Several governmental and civil organisations have developed EWSs to reduce and respond to the impacts of severe weather and climate events (Collins and Kapucu, 2008; Braman et al., 2013; Cuevas 2012; Basher, 2006Alfieri et al., 2012; Borga et al., 2011; Abon et al., 2012). Mude et al (2009) have developed an EWS for impending drought for pastoralists in Kenya, using climate information as a key determinant in the forecast. FEWS NET[48] is a major provider of early warning information on food security. As a part of DRR efforts, multi-hazard EWSs incorporate various stakeholders, including government organisations and various implementers who contribute together to achieve the desired level of collaborative risk management. The collaboration is suggested to be carried out through four interacting elements that comprise EWSs: 1) risk knowledge; 2) prediction, monitoring and warning services; 3) dissemination and communication; 4) response capacity (Basher, 2006). However, building a EWS is only the first step. It requires also institutional capacity to respond to the information and, therefore, a holistic approach on the assessment of the benefits of EWS is required (Fakhruddin & Chivakidakarn, 2014.).

There are two approaches for EWS: top-down and bottom-up. The top-down approach incorporates various tools and guidelines to build and implement EWSs. The importance of coherent technologies and effective EWSs are acknowledged for general approaches of risk management of natural disasters. These general approaches encompass elements that can be applicable to different contexts and cover unequivocal policy objectives and directions. On the contrary, bottom-up approach look at the ‘street-level’ actors who translate the policy guidelines into action (Lipsky, 1980; Barrett, 2004). The bottom-up approaches depict implementation process differently. in

[48] The Famine Early Warning Systems Network; http://www.fews.net/

that participating actors are based on commitment and self-selection rather than obligation (Hjern and Porter, 1981).

Aim and objectives

The aim of this paper is to identify a policy framework and assess the challenges in sharing and utilising early warning information for DRR, as a tool to adapt to the current impacts of natural hazards and improving CCA. A hybrid approach, that combines the above two perspectives, is adopted.

Through a comparative and complementary case study of two Southern African countries, the objectives of this paper are to (1) identify frameworks and actors relevant to CCA, DRR and EWS in the national policy, (2) assess the challenges from the implementer's perspective in sharing and utilising early warning information, and (3) suggest potential improvements followed by recommendations.

Firstly, we study the existing policy documents and institutional organisations that are related to CCA, DRR and EWS in Malawi and Zambia. EWS in the context of this paper is the provision of seasonal, climatological forecasts for predicting pro-longed dry spells, and warnings of severe weather based on medium- to short-range weather forecasts for predicting floods. We incorporate ideas from different studies on policy analysis and evaluation (Patton and Sawicki, 1993; Howlett and Ramesh, 1995) to develop a framework that will be applied to analyse the current policies and organisational bodies. Secondly, we investigate EWS from the implementers' perspective; the street-level actors, and their interactions in the process of implementation on the local level. While central governments' role is important for the coordination and planning of disaster reduction measures and response capacities, regional and local implementers are involved in providing actual services by utilising their local presence. Policy documents and other evaluation reports may suggest guidelines and recommendations but the way policy implementation is unfolded is worthwhile to investigate.

Scope

This paper is based on a qualitative research conducted in Malawi and Zambia. Although there is progress in policy and relevant governmental structures, recent studies show that Malawi and Zambia are poorly prepared and still highly vulnerable to climate-related disasters (Tall et al., 2013). One of the world's least developed countries, Malawi is a small, landlocked country suffering from decades of underdevelopment. Being mainly resource-poor rural communities, the majority of the people in Malawi are largely dependent on subsistence rain-fed agriculture. Over the last decades, Malawi has suffered from intense rainfall, changing rainfall patterns, prolonged dry spells, and seasonal droughts, which exacerbate poverty in the country. Zambia's economy is largely based on copper mining and agriculture. Its relatively large and impoverished rural population (approximately 64 per cent of total population) largely relies on rain-fed agriculture (Kanyanga et al., 2013). Malawi and Zambia have one rainy season, which runs from November to April, and the rest of the year, from May to October, is considered to be the dry period. This makes the countries vulnerable to the impacts of climate abnormality, which would pose consequent challenges for food security.

Theoretical consideration

In the field of policy analysis, a framework of policy process or cycle is considered to be useful for its basic and simple template that can be easily compared and systemised in the policy debates. Its assumptions of sequential evolvement of discrete stages and phases of policy have contributed to a better understanding of policy making (Jann and Wegrich, 2006). Despite its analytical conciseness, the assumptions of linearity may limit the knowledge. We argue that the dynamics of complex processes between policy designs and implementation is important at the same time.

Top-down approaches assume that a policy will be successful if there are clear and consistent goals, a valid intervention through hierarchy and authority that can carry out the command from the top, and sufficient resources and other favourable conditions for implementation. Top-down approaches assume that policy failure is caused by different applications of original design of policy into the field level (Sabatier, 1986; O'Toole, 2004; Cairney, 2009; Hupe, 2011; Hanberger, 2013). On the other hand, the actors and actions in the front-line, represented as a concept of 'street-level bureaucrats' (Lipsky, 1980), have been emphasised in bottom-up approaches. The difference between the original policy design and the actual implementation is less important in bottom-up approach. Instead, the discretion by local actors is underlined. Policy is not in complete shape when it is brought to implementers. Policy process is not necessarily sequential progress; thus implementation cannot be understood as a set of discrete activities (Nakamura, 1987; Carlsson, 2000). There are dynamic processes between policy designs and programme implementation. In this paper, we attempt to synthesis these two approaches to benefit from the two distinct and polarised perspectives of policy implementation analysis

Firstly, we examine DRR and EWS policy documents and organisations in Malawi and Zambia, and compare implementers' perspectives in the two countries. The policy documents and organisational bodies related to DRR and EWS are examined with three criteria: 1) problems to be tackled and policy objectives – where we investigate problems that has been raised DRR environs and relevant policy objectives and design, 2) organisation structure – focused on the main organisational bodies in DRR and EWS, and 3) main functions of implication derived from the policies and organisations (see Table 1).

Table 7. Analysis criteria.

Analysis object	Focus of analysis
Problems and policy objectives	Boundary of problem, details of objectives and design
Organisation structure	Relevance to and application of DRR and EWS
Main functions	Programme implication related to DRR and EWS

Secondly, the implementers' perspective and their challenges are studied by using a bottom-up approach. In particular, the concept of 'implementation structure', suggested by Hjern and Porter (1981), is employed in our conceptualisation. Implementation structure can be suggested as an alternative unit of analysis other than individual actors and organisations level. It postulates a structure that is designed to support the implementation of a certain programme or service, such as disaster reduction and response. It may not be the whole organisations but only a partial department or section of the organisation that is joining this structure. The participating agencies share the common purposive actions that are achieved in the implementation structure while each organisation has different mandates compared to the actual implementation structure. As there is no approved disaster risk management policy in Malawi, the focus in Malawi was on the bottom-up approach, whereas in Zambia, the top-down approach receives more attention.

Data and Method

The study is based on the analysis of relevant policy documents and 45 semi-structured interviews conducted in Malawi and Zambia, including the government and private sector, NGOs, UN agencies, and other civil society actors. The interviewees were officers and managers whose work is closely related to DRR and CCA, humanitarian aid that includes emergency relief, water and sanitation, healthcare, and food security; and development programmes in the organisations. In Malawi, the interviewees were chosen mainly among the contacts of the National Meteorological Services (NMS). For Zambia, a comprehensive list of organisations in humanitarian and development was used for the initial contacts. Zambia Meteorological Department assisted in contacting other government departments in an official way.

Both researchers stayed in the field for the data collection for approximately three weeks. Despite the close collaboration with NMS in both countries, the researchers have maintained independent approaches to minimise the influence of government authorities as well as to limit potential bias. Information about overall objectives of project was sent out in advance and relationship between research project and collaborating agencies in the countries was explained before the interviews.

Policy and organisation review

The main purpose of analysing policy documents and organisations is to define, categorise, explore, and map the policy problems and related policy guidelines and discussion in a qualitative manner. The analysis criteria (see Table 1) were developed to help the task and output to be achieved. Table 2 shows the main findings of the analysis, and the following text complements and deepens the analysis.

Table 2. Summary of the policy and organisation analysis

	Malawi		Zambia	
	National Disaster Management Policy	**Department of Disaster Management Affairs**	**National Disaster Management Policy**	**Disaster Management and Mitigation Unit**
Problems (to be tackled) & policy objectives	· Currently no disaster management policy adopted. · Disaster Preparedness and Relief Act 1991 outdated.	· Financial capacity to prepare and respond to disasters weak; purely ad-hoc funding · Focus on response	· Absence of legal authority to the disaster management · To strengthen national capacities for effective disaster management	· Fragmented disaster management framework · To create a permanent unit within Government to initiate, implement and coordinate disaster management policies and implementation
Organisation structure (related to CCA & DRR & EWS)	· None	· Decentralised structure	· Disaster preparedness and timely response · Disaster prevention · Disaster mitigation and restoration of livelihoods · Coordination	· Decentralised structure · National, Provincial, District, and satellite
Main function (related to CCA & DRR & EWS)	· None	· Coordination of national level disaster response · National contingency plan · Disseminate weather and climate information to district commissioners	· Building domestic, international alliance for better EWS · Maintenance and upgrade communication infrastructure and general capacity of early warning	· Encompass different early warning information to formulate appropriate early warning information dissemination mechanisms

Disaster Risk Management Policy documents

Problems to be tackled and policy objectives

In both countries, the national disaster risk management policy has been the subject of continuous in discussion and development. In Malawi, in 1991, the government adopted the Disaster Preparedness and Relief Act which focused on the response to disasters. Twenty year later, a policy process was started in 2011 to develop a disaster management policy with a holistic approach. However, by 2014, the policy has not yet been adopted. This is hindering the DRR efforts on the national level, as there are no official guiding principles or funding allocated for disaster management. Malawi does, however, have a practical Handbook on Disaster Management.

EWSs are endorsed in current and drafted national level policy documents, which also emphasise the negative impacts of climate change in Malawi. Social Support and Disaster Risk Management is one of the themes in the

Malawi Growth and Development Strategy II for 2011–2016. The strategy clearly states that the DRR efforts in Malawi are poorly addressed, creating significant social, economic and environmental impacts of disasters. Furthermore, climate change is mentioned as one of the drivers behind increased impacts. The Strategy lists eight key strategies to achieve the medium-term expected outcome of attained strengthened capacity for effective preparedness, response and recovery; of which the development of an integrated national EWS is one. Furthermore, the draft National Disaster Management Act mentions the development of a EWS as one priority in disaster risk management. However, the draft Act is vague in defining the development and functioning of EWS, and speaks both of 'people-centred' information for early warning and 'scientific and technical modelling and forecasting for early warning'.

Zambia, on the other hand, has put in place a National Disaster Management Policy (GRZ, 2005), which provides policy direction and defines parameters within which the Disaster Management and Mitigation Unit and other organisations operate. The policy is comprised of four pillars: disaster preparedness and timely response, disaster prevention, disaster mitigation and restoration of livelihoods, and coordination. This policy is supported by other policy documents, including National Disaster Management Act No. 13 of 2010 (GRZ, 2010), and revised draft of Disaster Management Operation Manual of 2013 (GRZ, 2013) (there is also a 2005 version). The Act in 2010 provides the legal authority of disaster management policy and relevant government structure. Although subjective political influence and inadequate coordination may cause limitations, the policy provides a framework to promote a 'safety net' for protection of the population and integrate disaster management into national development in the future to overcome the structural weakness in managing hazard risks, vulnerable populations and the environment at risk.

The effective EWS is suggested as one of key guiding principles for the policy. The policy indicates three primary elements of EWS; forecasting, processing and dissemination, and undertaking appropriate and timely actions. A support of a well-equipped core team, communication infrastructure and general capacity related to early warning systems are underlined. The policy also highlights the coordination among different actors, including NGOs, private sectors, and other government wings as well as international alliances for improved early warning capacity. The most relevant government bodies as providers of early warning services are Zambia Meteorological Department (ZMD), Zambia Environmental Management Agency, Zambezi River Authority, Ministry of Energy and Water Development and Ministry of Agriculture and Livestock. The NGOs are also encouraged to provide relief and early warning information and the Government, in particular the Disaster Management and Mitigation Unit (DMMU), is to act as clearing house for information related to early warning.

Disaster Management organisations

Structure and policy function

In Malawi, the Department of Disaster Management Affairs (DoDMA) is the national level coordinator of disaster management affairs, established through the Disaster Preparedness and Relief Act of 1991 and working under the Office of the Vice President. It is responsible for the coordination of the national level disaster response efforts, creating the national level contingency plan and responding to large-scale disasters. Along with other relevant stakeholders, DoDMA receives the seasonal forecast issued by the DoCCMS and disseminates it to the district commissioners. The Malawi Vulnerability Assessment Committee (MVAC) is responsible for the food security assessments twice a year.

In Zambia, the DMMU is the main disaster management and coordination institution, a permanent unit within government, which operates under the Office of the Vice President. After the severe drought and consequent crop failure in 1992, Zambia recognised the fragmented disaster framework that leads to reactive and ad hoc responses. The government took the decision to create the DMMU to initiate, implement and coordinate disaster management policies and programmes. The National Disaster Management Act No. 13 of 2010 supports the implementation of all disaster management programmes and activities in the country, such as central planning, public warnings, and decisions on national strategic reserves of essential commodities. The DMMU is structured in a decentralised manner. The Unit is divided into two levels, national (central) and provincial. In addition, different levels of committees from national, provincial, district, and satellite (sub-district) levels are incorporated in the organisation. For the disaster response, emphasis is on the provincial level where they can collaborate with cooperating stakeholders in the local level. The Central Unit would react when the scale becomes overwhelming but the Unit and the committees in the central level are in charge of vulnerability assessment and contingency planning.

The function of EWS under the DMMU is still in development. Internal collaboration among government bodies, NGOs, and private sector in Zambia as well as international alliance with other country government and organisation makes slow but steady progress. Similar programmes exist in Zambia that are operated by different agencies, for instance: the Zambia Emergency Preparedness and Response Information System (ZEPRIS) by the World Food Programme (WFP) and ZMD, the Integrated Water Resources Management Information System (IWRMIS) by Ministry of Energy and Water Development, and the National Early Warning Systems by the DMMU. Seasonal rainfall forecast, Hydrological conditions, and preliminary/final crop forecast are the information sourced from these different initiatives. It is the DMMU that would regularly share the information and forward the use of triggers in the on-going situation. However, its current function is limited. One of the challenges of the DMMU for having parallel streamlines of different early warning initiatives is the inefficiency in generating early warnings. Thus, the DMMU needs to overcome the problem of coordination in decision-making.

Policy implementation and challenges

Although policy guidelines exist, policy implantation can be unfolded rather differently within specific contexts. What we have noted here is an implementation structure, a structure with common purposive intention to implement programmes and services.

In Malawi, the DoDMA and the Ministry of Agriculture (MoA) both have the means to disseminate information they receive from the DoCCMS to the community level. DoDMA shares the seasonal forecast and medium-range bulletins to district commissioners, and the Ministry of Agriculture has extension officers working in the communities. However, particularly with the agricultural extension workers, the resources are extremely limited and the importance of civil society actors, namely NGOs, increases. The MoA has initialised collaboration with an NGO to improve the dissemination of the agricultural information. A challenge identified by the DoDMA in the use of early warning information on the community level by the district commissioners was the lack of knowledge on how to respond to the information. Therefore, there is a clear need for capacity building not only among the communities.

Furthermore, a bottom-up approach to DRR and CCA was heavily present in flood and drought-prone areas in the country, as there are several NGOs working on the community level, explicitly linking CCA and DRR in order to increase the preparedness and response of the communities to the impacts of natural hazards and climate change. According to the interviews among NGOs, community-based adaptation to climate change and warning services were a key measure in many of the flood-prone communities; rain gauges and simple flood level indicators were used to measure the flood risk in the up-stream of a river, mobile phones were used to inform people living in the down-stream. However, the connection between the top-down link among CCA, DRR and the provision of EWS was lacking in most cases, and many of the interviewees questioned the benefits of a national-level multi-hazard EWS. The oft-mentioned reasons behind this were firstly the capacity of the DoCCMS to issue reliable and timely EWS, and secondly the capacity of the people to receive and respond to the early warning message on time. Therefore, the community-based DRR and CCA measures were considered to be most effective, as they are giving the people in downstream sufficient lead-time to evacuate.

The NGO's focus on the community-based DRR and CCA measures is an efficient tool to cope with the impacts of current hazardous weather events. However, there is a risk that after the donor funding of the NGO's runs out and the programmes end, the measures slowly degrade. Therefore, adaptation to climate change is not necessarily improved by the current DRR efforts which are an efficient short-term solution in the current environment without proper disaster management policy and act in place, but should be used only as a secondary measure after the approval of the Policy and Act and the development of a national EWS.

In Zambia, a decentralised structure has not been yet fully implemented as a policy guideline. For example, one of the staff in a district agriculture department office, where weather observation station is installed, pointed out all the collected data from the station is sent to ZMD central office for analysis. The district office would only receive the generalised information that may not be fully applied to their implementing area. Although the staff in the district office recognises the use of collected information (for example current/historical data and trends of temperature, precipitation, and evaporation/soil moisture, which can be shared with local famers and other population) the information is not used directly in the district or provincial level. This is due to limited facilities and human resource in the district, as well as inactive communication between rural populations is another problem. Thus DRR actors and other users of EWS who consist of the implementation structure under the decentralised governance became dependent on the central level that would cause again unintended inefficiencies and inappropriate use of resources.

There are some other challenges for effective use of EWS. Many shortcomings in the current weather information hinder actual DRR operation. Mainly descriptive seasonal forecast, i.e. 'below normal', 'normal', and 'above normal', with a large scale on a national level (although some indications are made at the provincial level) and ambiguous information on rainfall for agricultural use. Given that Zambia is a country with a vast territorial size and varied climate conditions, a certain degree of specific local information is essential. Sometimes self-determining and independent trigger mechanisms exist in the local. However, farmers and rural population require more than indigenous indicators in order to ensure their crop yield and food security.

Discussion and Conclusions

CCA and DRR policies need to address the root causes of vulnerabilities, i.e. lack of capacity of the national and local stakeholders, and develop long-term engagement of various actors. Reducing risk is not only about minimizing the damage caused by a disaster in terms of lost lives and livelihoods, but also to resolve the root causes of disaster in a broader sense through enhanced adaptive capacity and strategy for development (Mitchell et al., 2010). Both of the case countries have made substantial progress by recognising the problems of capacity and incorporating CCA and DRR into national development plans; also highlighting EWS as a tool to adapt to the impacts of climate change and natural hazards.

The major difference between Malawi and Zambia is the extent of central level policy establishment on the holistic Disaster Risk Management (see Table 2). While Malawi is still in progress for the approval of the national policy on disaster risk management, in 2005 Zambia had formulated the policy for disaster management, showing strong governmental lead in disaster management. Zambia has decentralised its disaster management structure to increase the level of efficient and effective service delivery. The policy design supports the roles and responsibilities for authorities at each level. Currently, Malawi has a decentralised structure in disaster response, but the lack of a holistic disaster management policy, considering the entire disaster management cycle, has hindered the creation of decentralised disaster management structure. However, a decentralised structure is endorsed in the draft Act.

As the limited capacity and resources are deterring direct use of EWS at the district/provincial level, the efficiency of information sharing and service delivery is rather disrupted. In Malawi, CCA and DRR and EWS are heavily linked on an NGO-level. The community-based DRR measures are used and are considered as the most effective tool to adapt to current and future impacts. A challenge with NGO community-based warning systems is the sustainability of the programmes. Therefore, more emphasis and funding should be put to developing an efficient national level multi-hazard EWS and ensure the dissemination of the information, which could be done for instance with the aid of NGOs. In Zambia, the current parallel EWS systems may not exhibit the full capacity due to the challenges of integration. Different initiatives supported by different government departments and foreign donors are a barrier to integration which needs to be overcome. As one of the challenges at the community level, strong governmental leadership affects the dependence on government, particularly on the central level. More improvement in down-scaled information for a certain district and provincial level is essential.

CCA and DRR efforts should enhance the link between the top-down and bottom-up approach for improved use of EWS. Though the complimentary role of policy and implementation is self-evident, it requires careful consideration of both policy makers and downstream implementers. Given the current barriers of operation, a stronger connection would require funding and capacity building of all relevant stakeholders.

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Anticipatory Governance for Social Ecological Resilience

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Anticipation is increasingly central to urgent contemporary debates, from climate change to the global economic crisis. Anticipatory practices are coming to the forefront of political, organizational and citizens' society. Research into anticipation, however, has not kept pace with public demand for insights into anticipatory practices, their risks and uses. Where research exists, it is deeply fragmented. This paper seeks to identify how anticipation is defined and understood in the literature, and explore to what extent anticipation is considered a core mechanism for adaptation? We use a social ecological resilience lens to examine these questions. We illustrate how varying forms of anticipatory governance are enhanced by multi-scale regional networks and technologies, and by the agency of individuals. Finally, we discuss how an anticipatory approach can inform adaptive institutions, decision-making, strategy formation and societal resilience.

Introduction and Background

Anticipation has been widely studied within a number of different disciplines including fields such as biology (Louie 2009; Louie & Poli 2011; Poli 2009, 2010, 2011), psychology (Gilbert &Wilson 2007; Seligman et al 2013) resilience (Almedom et al. 2007, Almedom et al. 2009; Martin-Breen & Anderies 2011, Zolli & Healy 2012), futures study (Miller 2006; 2007; 2011; 2012) and governance (Fuerth 2009; Karinen & Guston 2010).

All attempts to 'understand the future', imagining and benefiting from the future are modes of anticipation, which is a constant feature of human behavior (Poli 2011). Currently, as certainty in the past as a forecaster of the future is questioned, prophecies and ideas of imaginable futures are the focus of substantial current discussion, for example, the spread of social media in popular culture, 'forecasting' of financial markets and modeling of Earth's ecological boundaries. Such anticipatory practice, in situations of noteworthy and alarming change, are conceivably highly beneficial to imagine how to elucidate complexity and decipher 'wicked' problems, and engage with new mechanisms to harness the future. Anticipation helps to raise awareness about the type of futures mankind may encounter and sensitise society to the influences and consequences of choices and actions of individuals and societies (Poli 2009, 2010, 2011).

To date there have been partial systematic efforts to construct in-depth understanding of different forms of anticipation, their uses and risks. The research foundation is in progress, but it is disjointed (Poli 2010). In the cognitive sciences, Gilbert and Wilson (2007) have proposed the controversial notion of 'prospection' - the psychology of imagining the consequences of hedonic future events (Fukukura et al. 2013). Critics of Prospection

Theory say it reflects deterministic explanations of cognition as it does not advance conscious decision-making and free will. On this basis, Seligman et al. (2013) propose to change the discipline of psychology, by radically overturning the entire discipline from a primarily past-oriented field to a primarily future-oriented one. The field of futures studies focuses on building a theory of adaptation where we still lack understanding about how societies cope, prepare and adapt to change (Toffler 1970). This discipline is generally understood to be strong on practice and facilitation rather than on its theoretical foundations. The discipline of social ecological resilience believes that humanity is now influencing every aspect of the Earth on a grand scale (e.g. Rockstrom et al. 2009, 32). The planet has entered a new geological era called the Anthropocene (Zalasiewicz et al. 2010). The impact of humans on the planet are thought to be significant, interconnected in complex ways, and contain a risk of an irreversible and uncertain sequence of changes, leading societies into a profoundly different future to anything been experienced by humans in the past (http://www.anthropocene.info/en/home): "The challenge is to anticipate change and shape it for sustainability in a manner that does not lead to loss of future options" (Berkes et al. 2003, 354). Hence, we imagine that anticipation is a critical component for building resilience. Yet, apart from a few exceptions (See Tschakert & Dietrich 2010), resilience literature does not drill down further into the tools and methods to actually build resilience in practice through anticipatory approaches.

Our work is contextualized within the SES (social ecological systems) research discipline. The overarching aim of this research is to explore the importance of anticipation to building resilience of coupled ecosystems and livelihoods under a changing climate by developing an approach that is capable of framing and enhancing the potential of anticipatory practices for individuals, organizations and society. In this paper we aim specifically to address the following question: how is anticipation defined and understood in the literature, and to what extent is anticipation considered a core mechanism for adaptation?

Material and Methods

We conducted an extensive review of the literature ranging from philosophy to resilience, planning and futures to identify the definitions of 'anticipation' broadly. Specifically we focus on the literature on resilience and anticipation, and the relationship with existing forms of environmental governance. The paper then discusses the findings and speculates on the risks and uses of such anticipatory practices. We conclude with some thoughts on the potential opportunities to lay the foundation for understanding and creating future-oriented dialogue to enhance decision and policy-making for social ecological resilience.

Results

Anticipation has been widely studied within a number of different disciplines, and has been described as a discipline in its own right (Miller et al. 2013) (See Table 1). Whilst rooted in the field of theoretical biology, Rosen's (1965) Theory of Anticipatory Systems appears across disciplines, and has been extensively applied to human systems. While acknowledging that little is understood about anticipation, Poli (2010) concludes with the following opinions:

(1) Anticipation comes in different forms, e.g. explicit and implicit, and different types of anticipation may be at work simultaneously (either complementing or counteracting each other).

(2) Anticipation has been a major evolutionary breakthrough, and if Rosen's theory (1985) holds true, anticipation may be deeply embedded in the functional structure of organisms.

(3) Anticipation's abstract nature depends on hierarchical, or self-referential loops, which imposes severe constraints on the modeling of anticipation systems.

Rossel (2010) stresses that the concept of anticipatory systems is merely another way of framing reality, so that even with the most sophisticated tools for modeling, we cannot escape our critical inability to be outside ourselves.

Table 1. Definitions and approaches to anticipation

Subject	Definition	Themes addressed	Sources
Philosophy	According to Husserl, anticipation is the way in which the merely co-presented is present in perceptual experience. Heidegger's "Philosophy of Death" describes anticipation as "the possibility of understanding one's own most and uttermost potentiality-for-Being--that is to say, the possibility of authentic existence"	Anticipation as a component of consciousness; humans' expectations	Husserl 1991; Bloch 1995; Heidegger 1962, 260
Biology	Rosen's Theory of Anticipatory Systems states that: "An anticipatory system is a system containing a predictive model of itself and/or its environment, which allows it to change state at an instant in accord with the model's predictions pertaining to a later instant." His theory showed that anticipation is not limited to living systems. Poli (2010, 8) states, "non-living or non-biological systems can be anticipatory."	Theory of anticipatory systems	Rosen 1985, 341; Louie 2009; Louie and Poli 2010; Poli 2009; 2010; 2011
Psychology	Anticipation is imagining the consequences of unknown future events	Cognitive studies	Seligman et al. (2013)
Physics	Dubois (2000) distinguishes between weak anticipation: when systems use a model of themselves for computing future states; and strong anticipation: when the system uses itself for the construction of its future states. With strong anticipation, anticipation is no longer similar to prediction (see planning below)	Anticipation can stabilize otherwise unstable states; Anticipation is stored in a system's potential energy	Dubois 2000; Ferret, 2010
Anthropology	In relation to climate change, Nuttall (2010, 23) states, "While adaptation is largely about responses to climate change, anticipation is about intentionality, action, agency, imagination, possibility, and choice; but it is also about being doubtful, unsure, uncertain, fearful, and apprehensive." Nuttall finds that anticipation may be a prerequisite for thinking about climate change adaptation.	Anticipation to orient human action; how people make choices and decisions based on predictions, expectations or beliefs about the future	Bennett 1996; Nuttall, 2010
Planning, futures	According to Fuerth (2009, 29), anticipatory governance is "a system of institutions, rules and norms that provide a way to use foresight for the purpose of reducing risk, and to increase capacity to respond to events at early rather than later stages of their development."	Anticipatory governance; forecasting, simulation, trend extrapolation, scenarios. Anticipation is well-developed in this field.	Quay 2010; Fuerth 2009; Karinen and Guston 2010; Miller 2006; 2011; 2012

Resilience	Anticipatory adaptation act on the best models of climate change impacts. They "are effective in creating systems that are able to maintain their state in response to the unexpected crises arising from climate change" (Martin-Breen & Anderies 2011, 48).	Anticipation is an important feature of resilience. Resilience literature mentions anticipation but does not seem to draw extensively upon anticipation theory.	Almedom et al. 2007; Martin-Breen & Anderies 2011; Berkes et al. 2003

Anticipation and resilience

The IPCC (2012, 5) defines resilience as "the ability of a system and its component parts to anticipate, absorb, accommodate, or recover from the effects of a hazardous event in a timely and efficient manner." Broadly, literature points towards social ecological system resilience encompassing anticipation, for example, Conway (2008) states that adaptation, and resilience, start with anticipation, surveying and forecasting; and Tschakert and Dietrich (2010) describe anticipatory learning as a key element for climate resilience, and anticipation was mentioned, but not elaborated on, as a key challenge in the seminal book Navigating Social-Ecological Systems (Berkes et al. 2003, 354). In the context of emergency events, Rogers (2011) highlights how anticipation and assessment, together with preparation and prevention, are important features of resilience. Rogers defines anticipation as "horizon scanning to identify potential dangers, registering those in a formal typology and recognition of the changing nature of risks that need to be continually identified and re-assessed" (2011, 55).

There is some consistency in the definition of anticipation in the context of resilience, but definitions vary between anticipation meaning foresight, preparedness and planning practices (see Wardekker et al. 2010), and being predictive/proactive, in contrast to adaptation (see Nuttall 2010). Nuttall (2010) describes anticipation is being about foresight, rather than expectation, as anticipation draws upon predictive capabilities, knowledge, experience, and skill. Anticipation is described as being about "intentionality, action, agency, imagination, possibility, and choice; but it is also about being doubtful, unsure, uncertain, fearful, and apprehensive." This literature distinguishes between foresight and prediction, with foresight emerging as an important strategy in building adaptive capacity. As Wardekker et al. (2010, 994) note, "planning and foresight/research are important instruments of anticipatory adaptation, which is specific to human rather than natural systems." and other scholars such as Hill (2013, 34) have a similar distinctions. Wardekker et al. (2010) emphasise the importance of information from research/foresight reaching local practitioners, but also the importance of taking onboard information from local practitioners (implying a two-way flow of information to build resilience).

Gómez-Baggethun et al. (2012) explain that, according to resilience theory, traditional knowledge evolves over time, on the basis of long-term observation and responses to crises. This means that long-term observation feeds into traditional knowledge, which is necessary for resilience, so we can therefore consider traditional knowledge to be linked to anticipation and hence resilience. However, there is very little literature that makes the linkages between ecological knowledge and anticipation in the context of climate resilience. An understanding of ecological knowledge seems to only be implicitly stated in current resilience literature on climate futures. Nuttall (2010) also notes that little of the anthropology of anticipation appears to have entered discussions of climate change. Drawing on the example of a mine spill of the Aznalcollar tailings dam, Gómez-Baggethun et al. (2012) state that, in order to deal effectively with increased uncertainty due to environmental change, new governance approaches should use local understandings and utilise the memories (knowledge and institutions) of local cultures. This memory complements current science and technology in creating governance systems relevant to local contexts, and contributes to building long-term social-ecological resilience. Gómez-Baggethun et al. attempt to tease out what needs to be done in order to build resilient governance structures, in contrast to the resilience community (e.g. Folke et al. 2005), which is less prescriptive.

Wyckhuys and O'Neil (2010) emphasise the importance of combining farmers' and scientists' ecological knowledge in mutual learning systems, in effective management strategies that are adaptive and flexible. They perceive that this may provide a better understanding of the workings of local agroecosystems. While much of the literature emphasizes the need to build resilience into governance frameworks in order to build resilience, linkages between anticipation and local ecological knowledge is broadly missing from resilience literature. However, Valdivia et al. (2010) do make the more explicit linkage between local knowledge with anticipation; they imply that new local knowledge can inform adaptive processes, which requires three steps: an assessment of local knowledge, development of future scenarios, and use of participatory research can help identify alternative adaptation strategies.

It is clear from the aforementioned literature, that anticipation is a critical component for building resilience. The use of local ecological knowledge in the design of governance frameworks for climate resilience is important. Systems of anticipation may be more effective if an understanding on local ecological knowledge is taken onboard. Folke et al (2005) describe networks and social learning in a less defined way, whereas futures studies and in fact other resilience scholars are more prescriptive.

Anticipation and governance

Over the past decade resilience scholars have focused on the concept of adaptive governance (e.g., see Folke et al. 2005). Adaptive governance encompasses and identifies adaptive response strategies associated with uncertain environmental risk. The important feature of adaptive governance is that societies are flexible in their response strategies to environmental crisis. Governance includes "all processes of governing, whether undertaken by a government, market or network, whether over a family, tribe, formal or informal organization or territory and whether through laws, norms, power or language" (Bevir 2013). Adaptive governance requires that governing processes take place through nested networked structures. In contrast to traditional top-down approaches, polycentricity requires creation and dissemination of detailed and current information from the bottom-up to support central decision-making processes (Ostrom 2010). This is evident in the emergence of 'citizens as sensors' (Goodman 2007). Citizen science describes bottom-up communities or networks of citizens acting as observers in some domain of science. For instance, in the US many farmers now have elaborate mapping and monitoring systems for their fields and crops that are more detailed and current than those information held by central agencies. In a successful climate early warning system in the Sahel, a bridging organization facilitated a network of government, scientists, NGOs to provision and process real time monitoring rainfall data relevant to communities, with those who could take preemptive early action to build resilience in the face of recurring crisis (Boyd et al. 2013). Understandings of adaptive governance have helped different communities of practice to better coordinate practices of living with uncertain futures.

More recently there has been a policy shift toward understanding environmental change and uncertainty in the context of forecasting/predicting change. Methods and approaches that present opportunity for better anticipating future changes are in demand. Anticipation is becoming an important ideal alongside other values in environmental governance such as democracy, justice and accountability. This is aligned to growing knowledge about attributing the impacts of extreme events to greenhouse gas emissions (See UK Met 2014). As someone has to bare the costs of the consequences of climate change, it becomes more imperative to forecast or anticipate what is coming ahead based on our current knowledge, models and creative imagination. Tschakert and Dietrich (2010, 22) state, "identifying and monitoring slowly changing variables such as rainfall patterns and integrating and reflecting on new knowledge allows for a better understanding of processes that are already underway. The same is true for anticipating possible events assuming observed trends continue. Monitoring enhances flexibility during times of disturbance and boosts the capacity for anticipatory action." In alternative futures studies for the healthcare sector, Bezold et al. (2008) find that biomonitoring devices could play a big role in achieving disparity reduction across income and racial/ethnic lines in the US.

Anticipatory governance is a new concept that has significant relevance for developing strategies under uncertain environmental futures. It is primarily grounded in resilience theory, however also features more broadly in organizational and health (Chi 2009 cf. Ozdemir et al, 2010), futures studies (e.g. Miller, many), Transitions Management (e.g. Loorbach et al) and to some extent in the regulatory impact assessment (RIA) literature (see e.g Nykvist, Nilsson, 2009.) Anticipatory governance involves changing short-term decision making to longer-term policy vision that includes the notion of foresight. Quay (2010) states that anticipatory governance anticipates a wide range of futures – assessment/analysis is undertaken across a range of scenarios (using criteria of: aggregation, extremes, sensitivity, risk assessment). Multiple strategies are anticipated, which are appropriate in the short and long term, given the range of possible futures. Changing conditions are monitored over time. Key precursors are identified which are associated with various possible futures. It is important for managing events instead of waiting until a climate-related or a regulatory/socio-economic event results in crisis. For example, the health sector has shown that coupling anticipatory governance with real time monitoring (RTM) can ground anticipatory outlooks in important ways. This involves "co-production" of knowledge, jointly designed by experts and citizens linking evidence base or informed decision-making to management. While the concept of anticipatory governance is important, it is also important to calibrate predictions. In the context of resilience and governing ecosystem services (e.g. water) under climate change such a framework has yet to be articulated.

Discussion and Conclusions

The paper identifies that there are varied and conflicting understandings of predicting and forecasting futures. We discuss how using futures can improve our understanding of anticipation to help different communities of practice to better coordinate practices of living with uncertain futures. We set out to examine the question: how is anticipation defined, understood and relevant to adaptation through a lens of social ecological resilience? We imagined that an anticipatory approach is helpful for improving our foresight capacity and in the co-design of solutions relevant to managing ecosystem services under climate change. The analysis has mapped out the different forms of anticipation from the literature and identified that there are varied and conflicting understandings of predicting and forecasting futures. It is expected that there exist varied definitions of anticipation and that a unified definition is does not exist (Poli 2010). In the relationship between anticipation and resilience many of the literatures mention anticipation, but authors do not go into detail about how resilience can be built in practice using anticipatory systems/theory of anticipation. For example, Almedom et al. (2009, 2) define resilience as "the capacity of individuals, families, communities, and institutions to anticipate, withstand and/or judiciously engage with catastrophic events and/or experiences; actively making meaning out of adversity, with the goal of maintaining 'normal' function without fundamental loss of identity." Anticipation plays a key role in this resilience research, but it is treated in a superficial manner.

The review has helped us to clarify how anticipation is both an active sense-making force and a way to anticipate dimensions of the present, with potentially important implications for the decision-making and choice-related questions that are at the heart of collective action (and inaction). It is imperative to continue to unpack theory of anticipation with regard to how it features as a core of everyday social relations and affects the ability to plan under uncertainty, and contributes to adaptiveness (Folke et al. 2005; Boyd & Folke 2012). There is further scope to elaborate on a theory of anticipation and how it relates to social ecological resilience. The review unearthed significant attention to the role of social ecological memory, local knowledge and anticipation. For example Gómez-Baggethun et al. (2012) say that new environmental governance approaches should use traditional knowledge and social–ecological memories of local cultures. To link research on social-ecological memory and anticipatory governance is an area that would benefit from further focus.

Many fields are looking at anticipatory governance, including public health (Ozdemir et al. 2009), geography (Goodchild 2007), conservation (Barlow et al. 2010) and climate change (Boyd & Cornforth 2013). Themes are emerging around citizen science, networks and volunteering of data sharing. In many parts of the world networks are acting as local early warning systems in the face of a changing environment, ranging from the detection of disease such as Ash dieback and real time monitoring to help governments detect early onset of famine (Boyd et al. 2013).

Risks and limitations of an anticipatory approach

We identify a number of limitations to the anticipatory approach. There are divergent views on what anticipation means, resulting in an ambiguity of meaning. This relates to absence of theory and lack of empirical cases of anticipatory approaches to date. Secondly, anticipatory approaches in the context of resilience could be considered deterministic (overlooking freewill) or predetermined in that people cannot question sustainability as the end goal. This reflects criticism encountered in the applicability of resilience for social systems. While the complex adaptive systems approach aims to shift thinking from predetermined mechanical and deterministic assumptions about nature to a greater dynamic and organic approach (http://www.stockholmresilience.org/21/research/what-is-resilience/research-background/research-framework/complex-adaptive-systems.html) critics argue that both multiscalar system complexity and agency (individual and collective) need to be more thoroughly explored if resilience is to continue to have resonance with the social sciences (Davidson 2010; Jernek & Olsson 2008). In developing a theory of anticipation it would be desirable to avoid such a polarized debate.

Anticipation has been widely studied within a number of different disciplines and the research base is in development, but it is fragmented. We found that anticipation is defined in different ways depending on the discipline. Social ecological memory features strongly across the literature. There is scope for further development of anticipatory theory. Futures Studies and Transitions Management may provide insights about how to overcome the limitations of anticipatory governance in ways that address politics, complexity and agency (participation of individual and collective).

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Assessing Climatic Impacts through the Lifecycle of an Urban Environment

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Climate change adaptation and mitigation have led to a phenomenon of assessing the climatic impacts of urban environment with various assessment tools. Few assessments still take account the whole lifecycle of the urban environment, and the assessments do rarely cover the various levels of urban planning. In the paper, the assessment of climatic impacts is outlined from the point of view of various levels of urban planning.

The question is approached by using research through design as a method, applying available assessment tools to an urban plan. The research is part of a multidisciplinary research project Integrative Urban Development Concept: Case Sustainable Winter City (2012–2014), based on a Living Lab experiment in city of Oulu, northern Finland, where a new Hiukkavaara neighbourhood for 20 000 inhabitants is being constructed.

As a conclusion it is shown that the impact assessment methods can be characterized depending on the planning level. By recognizing these methods, the climatic impacts can be assessed through the whole lifecycle of an urban environment.

Introduction and Background

Integrative Urban Development Concept

The University of Oulu has launched together with the City of Oulu and their partner companies (Oulun Energia, Sonell Oy, Skanska talonrakennus Oy and Hartela-Forum Oy), a multidisciplinary research project called *Integrative Urban Development Concept: Case Sustainable Winter City* (INURDECO, 2012–2014). The research project investigates integrative urban development practices, tools and city block level concepts needed in the design and construction of a Sustainable Winter City. The project is funded with EU structural funding by TEKES, the Finnish Funding Agency for Technology and Innovation.

The research project involves a Living Lab experiment in Oulu, northern Finland, where the new Hiukkavaara neighborhood for approximately 20,000 inhabitants is being constructed. The planned Hiukkavaara center will also offer services for approximately 40,000 people living in the surrounding areas. Hiukkavaara is being designed as a Sustainable Winter City, the new international pioneer of northern urban planning. In the concept of Sustainable Winter City, special attention is paid to *adapting* to challenging climate conditions in arctic areas and *mitigating* negative climatic impacts of the city structure by adopting energy production and energy efficiency as a new element in urban planning.

Adaptation and mitigation

Climate change mitigation and adaptation both represent human responses to climate change. According to the Intergovernmental Panel on Climate Change [IPCC], adaptation and mitigation measures complement each other as strategies for reducing and managing risks of climate change. Mitigation aims to emissions reduction, which can reduce climate risks in the future and create ways for more effective adaptation. Adaptation seeks to avoid harm of actual or expected climate and its effects, or exploit beneficial opportunities created by it. (IPCC 2014, 3; 17; 32.)

In the recent scientific understanding, summarized in the most recent IPCC Assessment report AR5, importance of integration in adaptation and mitigation is being emphasized. Adaptation and mitigation both seek to reduce and manage risks of climate change as a human intervention. Due to this intervention, they can also create new risks or benefits. To be able to response to climate change strategically, also the risks and benefits created by the adaptation and mitigation actions should be taken in consideration. Yet, the best balance between adaptation and mitigation has proven very hard to define, as the situation changes in time depending on the adaptation and mitigation actions that are being implemented. Despite of the disagreement and uncertainty related on these issues, it is acknowledged that the negative impacts of adaptation and mitigation actions are in every case lower compared to situation with no intervention at all. (IPCC 2014, 32–33.)

Adaptation and mitigation in stages of (urban) planning

The preliminary hypothesis of the INURDECO research project is that the concept of Sustainable Winter City with new kinds of architecture, energy and service solutions can be better obtained through an integrative, city block based approach, compared to single plot or property based urban development. This also challenges the traditional hierarchical land use planning system in Finland, where levels of planning are distinguished between national land use objectives, regional planning, local master plan and local detailed plan.

The national land use objectives, regional planning and even local master plans are more strategic in nature, as they provide guidance regarding the community structure, cultural or natural heritage, sustainable development, economy of the local structure and avoidance of environmental hazards. The local detailed plan gives guidance to more detailed organization of land use, building and development considering local conditions, townscape and landscape, good building practice, promoting the use of existing building stock and other steering goals inherited from the strategic planning stages. (Finnish Land Use and Building Act, chapters 3–7.)

In the hierarchical land use planning system, the national land use objectives, regional planning and local master plans are considered best suitable to form strategies for land use planning, as their timespan reaches longer to the future (Finnish Land Use and Building Act, chapters 3–7). Same kind of understanding also applies to planning and implementation of mitigation and adaptation measures. More far-reaching strategies are needed, as some of the near-term responses to climate change may also limit future choices. (IPCC 2014, 36; Juhola & Westerhof 2011.) In fact, many adaptation strategies in developed countries are currently focusing on government led anticipatory adaptation and adaptation planning compared to reactive responses (Berrang-Ford, Ford & Paterson 2011).

Yet in both cases, it has proven important that planning and implementation are enhanced through complementary actions through different timescales. Adaptation and mitigation strategies most likely have to be adjusted, as new understanding is created during the process (IPCC 2014, 34). For example, Juhola and Westerhof (2011) point out that the Finnish National Adaptation strategy has proven to be an ineffective tool due its lack of vertical integration and origins from the national level. Also Preston, Westaway and Yuen (2011) have claimed that there is a need to make the adaptation more integrated to mainstream policies, but the current adaptation plans still treat it in a narrow, disconnected manner.

Similar gaps have been identified also in land use planning processes. Strategies outlined in the zoning plan do not always transfer to realization plans, as the targets that are set may be too abstract or the presented solutions are not flexible enough for future needs (Staffans, Kyttä & Merikoski 2008). Moreover, the hierarchical land use planning model has been criticized for being slow, expensive and not able to respond to the needs that arise from the execution phase of the urban environment. For example, the top-down model manages often poorly to anticipate and exploit economic benefits emerging from project-based initiatives of construction or real estate businesses. This may even lead to execution of projects contradictory to areal vision. (Hentilä, Rönkkö & Soudunsaari 2013; Lehtovuori & Maijala 2009.)

As described above, there are similar challenges in applying integrative development to climate change adaptation and mitigation planning and land use planning, not least due to the hierarchical model of administration. One focus of the INURDECO research project has been to take into scrutiny the assessment tools needed in the planning of a Sustainable Winter City with an integrative approach. The following chapters present the results of a research where available climatic impact assessment tools were examined through their applicability as a planning tool with an integrative, city block based approach. The key questions have been:

1) How do the criteria of the planning tools relate to both climate change mitigation and adaptation?
2) How do the criteria of the planning tools relate to the hierarchical land use planning system in Finland?
3) How can the assessment results be utilized in planning of the Sustainable Winter City block concept?

Material and Methods

Case study: city block concept in Hiukkavaara

Suburban areas with low density are considered to be less energy-efficient compared to high-density urban areas with central location (IPCC 2014, 59). Constructing new suburbs may build up a challenge for climate change mitigation, as the advantages of condensing the existing urban structure are lost. However, it is predicted that climate change, demographic changes, limited natural resources and increasing global integration will make northern parts of the globe economically and politically more attractive within 50 years, whereas southern parts become less suitable for living and investments (Smith 2011). This makes it inevitable to also design new northern communities in the future and therefore develop concepts for Sustainable Winter Cities with solutions for both mitigation and adaptation.

The case study is an example of such urban development, a Sustainable Winter City block concept planned to be situated in the new Hiukkavaara center. Altogether four block concepts were created by the research group of the Oulu school of Architecture and the Environmental and Chemical Engineering Research Group from the University of Oulu in the INURDECO research project to be utilized as a research platform. Other purpose of the concepts was to enhance horizontal integration among the INURDECO consortium by bringing new aspects for the City of Oulu and the partner construction companies in actual land use planning of the Hiukkavaara Center.

The case study concept presented in this paper includes an urban plan on a city block level with features for climate conscious living environment, transportation, services, recreation and energy supply. The solutions were based on a state-of-the-art-survey made by the Oulun School of Architecture in the INURDECO research project that covered international references of climate conscious urban development. Multidisciplinary expert group in workshops organized in the INURDECO project also reviewed the block concept during the planning process. The expert group consisted of representatives from the INURDECO consortium and invited experts from the fields of land use planning and city administration.

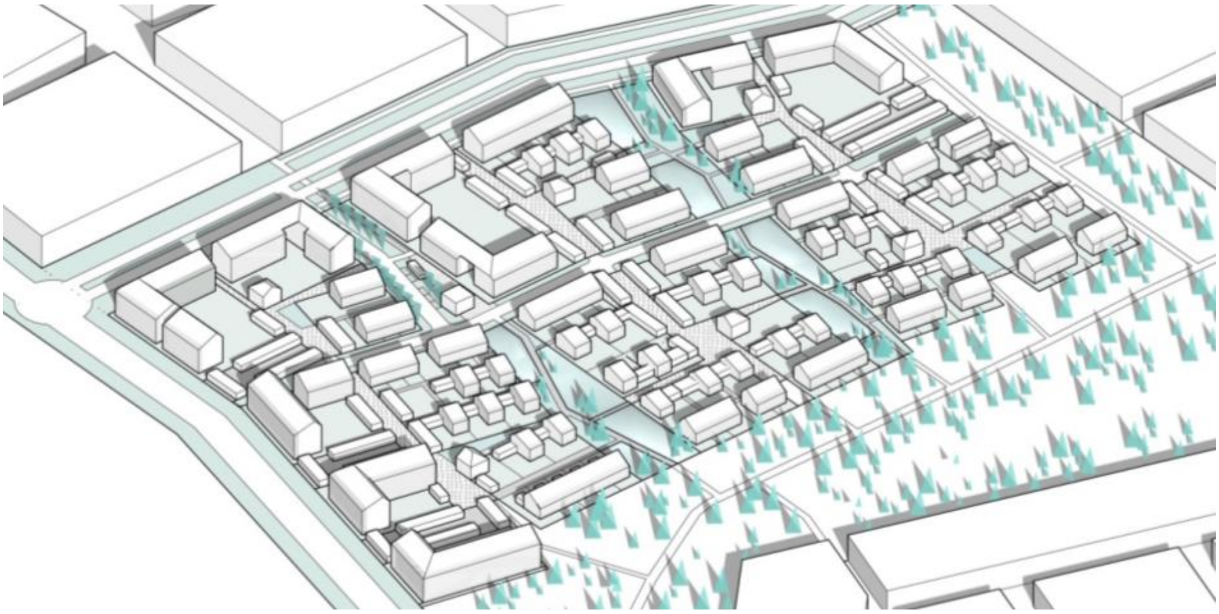

Figure 1. Case study: Sustainable Winter City block concept in Hiukkavaara.

Method

The aim of the Oulu school of Architecture was to examine through the city block concept, how could impact assessment be used as a planning tool in integrated planning of urban environment. The research questions were approached by using *research through design* as a method, where planning is both a tool and a result of the research (Barnacle 2013). This was conducted by applying available assessment tools to the Sustainable Winter City block concept. Selected assessment tools were the Japanese *CASBEE for Urban Development*[49] and the Finnish *PromisE*[50] and *KURKE*[51]. The aim was to utilize the assessment results to develop the block concept further, in order to improve climate consciousness of the plan. The assessment tools were selected on the basis of open availability in the Internet and the scope of the assessment. Selected assessment tools covered both wider aspects of sustainable development and more specific features of eco- and energy efficiency. In addition,

[49] Casbee for Urban Development -tool has been developed by Japan GreenBuild Council and Japan Sustainable building Consortium in 2007.
[50] PromisE-tool has been developed by the Finnish Ministry of the Environment, TEKES (Finnish Funding Agency for Technology and Innovation), MOTIVA (Finnish State owned energy consultation company), RAKLI (The Finnish Association of Building Owners and Construction Clients) and RT (Confederation of Finnish Construction Industries) in 2006.
[51] KURKE-tool has been developed by Aalto University and VTT (Technical Research Centre of Finland) in 2012.

the Sustainable Winter City block concept was assessed with energy calculation tool developed in the INURDECO research project by Environmental and Chemical Engineering Research Group, University of Oulu.

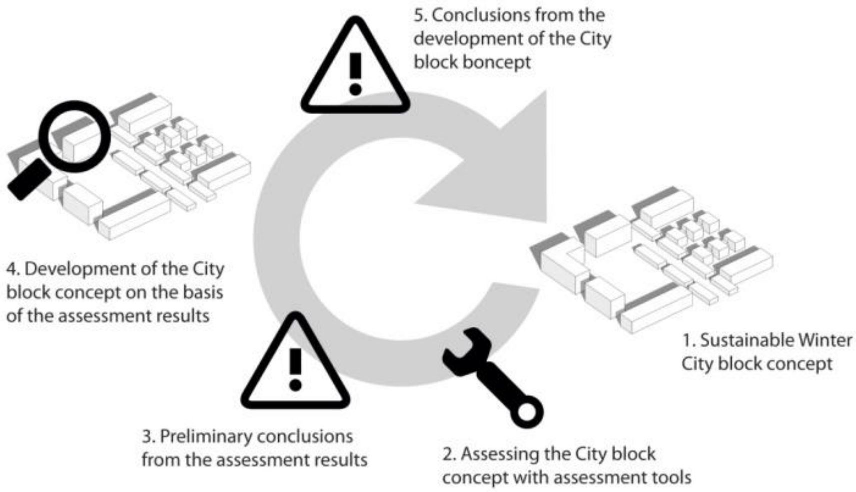

Figure 2. Process description: Developing the city block concept further on the basis of the assessment results

Results

The question number one was: "*How do the criteria of the planning tools relate to both climate change mitigation and adaptation?*" This was answered by identifying the adaptation and mitigation measures that were assessed in the tools. During the identification process, five broader categories of adaptation and mitigation measures emerged, characterized here as *Accessibility, Self-supporting services, Denseness of the urban structure, Energy solutions and Protective natural and urban structures* of the assessed urban plan. The question number two was: "*How do the criteria of the planning tools relate to the hierarchical land use planning system in Finland?*" This was approached by categorizing the assessed measures according to their relation to the hierarchical land use planning system. The question number three was: "*How can the assessment results be utilized in planning of the Sustainable Winter City block concept?*" In the following, the assessed measures are presented by the categorizations and as an answer to question number three, their applicability to the further development of the Sustainable Winter City block concept.

Accessibility

Question 1. Assessment criteria related to solutions promoting public transport and pedestrian and bicycle traffic were collected under category of Accessibility. This kind of transport-oriented development decreases direct and indirect energy use in urban areas (IPCC 2014, 59). It also has economic, social and environmental co-benefits such as reduced oil dependency, decreasing the level of health damaging, climate altering air pollutants and increasing physical activity. (IPCC 2014, 75–78.)

Questions 2 and 3. The assessment of measures considering passenger traffic is based on the central or peripheral location of the city block level plan in the wider urban structure. The assessed impact can be seen as a consequence of decisions made in the initial planning stages when defining the whole structure of the Hiukkavaara district in the regional plan and the local master plan, not as a planning solution made in the city block level planning. The distance from Hiukkavaara to the City Center of Oulu is approximately 7 km and the passenger traffic of the area will be somewhat based on private cars. On city block level, applicable measures related to accessibility are smaller of scale, compensating the challenges related to the distant location of the area. For example, by developing high quality bicycle and pedestrian routes, the short-distance transportation choices of the inhabitants can be affected.

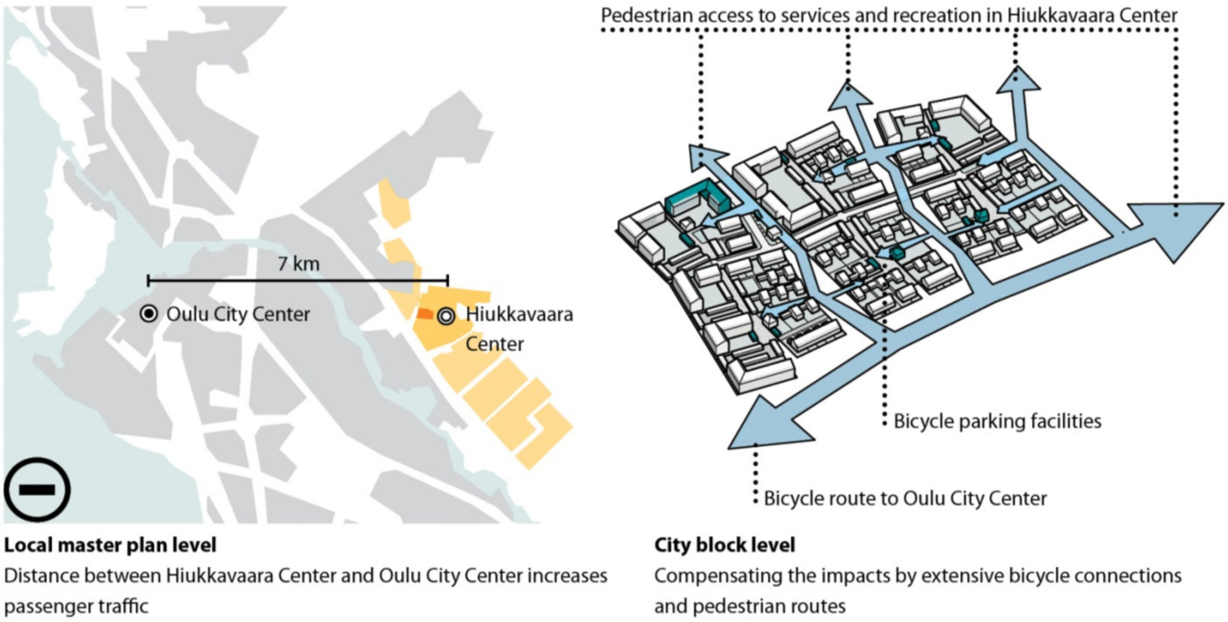

Figure 3. Measures for accessibility on local master plan and city block plan levels

Self-supporting Services

Question 1. Assessment criteria related to availability of local services were collected under category of Self-supporting services. According to the IPCC (2014, 59), mixed-use zoning and co-located jobs and homes improve energy efficiency of urban areas. There are also co-benefits related to commute savings, increased physical activity and social interaction (IPCC 2014, 75–78).

Questions 2 and 3. According to the hierarchical land use planning system, the service functions of the area are mainly defined in the earlier stages of planning. It is challenging to provide self-supporting services inside the block structure, if the city block level plan is not located near a service hub in the wider urban structure. In the case study, positive impacts of self-supporting services are gained through the comprehensive planning of service functions for the whole Hiukkavaara district made in the Hiukkavaara local master plan. These impacts can be strengthened by creating synergies between functions inside the block structure, for example by integrating working and living spaces and providing a platform for business opportunities.

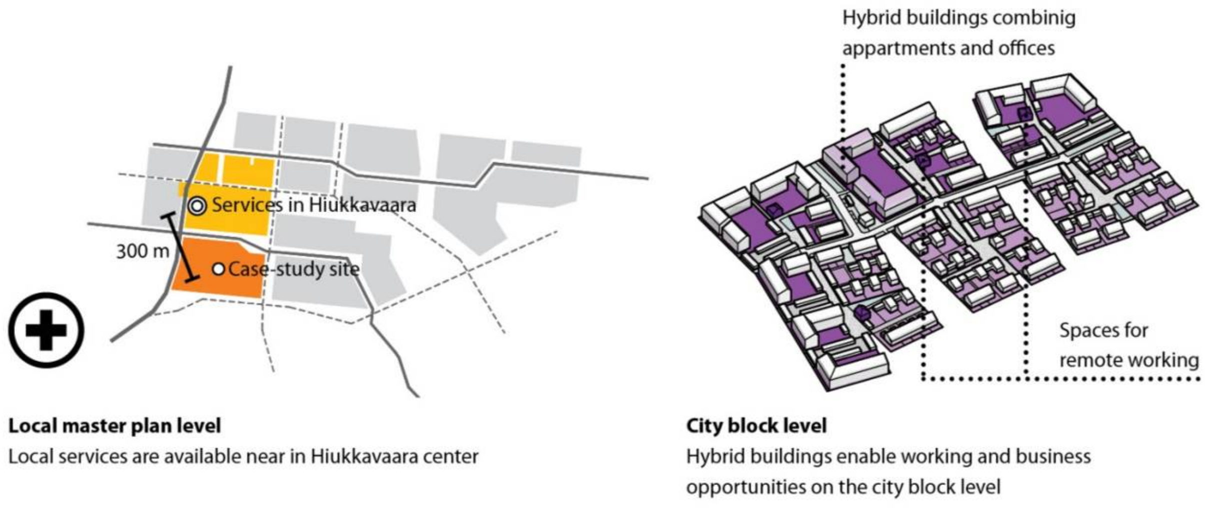

Figure 4. Measures for self-supporting services on local master plan and city block plan levels.

Dense urban structure

Question 1. Assessment criteria related to compactness of the urban structure were collected under category of Dense urban structure. Increased density reduces energy use in urban areas. Compactness also leaves space for land carbon stocks such as forests. In addition, compact urban structure links to transport infrastructure improvements presented above in the Accessibility and Self-supporting services -categories. (IPCC 2014, 59; 76.) Integrated co-benefits concern for example improved energy security via reduced oil-dependency and increased productivity via reduced travel times. Adverse side effects can be predicted via potentially higher exposure on air pollution. (IPCC 2014, 75–78.) Preventing deforestration also helps the protection of ecosystems (IPCC 2014, 49).

Questions 2 and 3. When establishing completely new urban areas like Hiukkavaara, these mitigation measures cannot be applied in the sense of densification of existing areas. However, compensating measures can be introduced by designing the new block structure to be as compact as possible. This minimizes the need for excess transportation and enables the efficient use of the new infrastructure that has to be built.

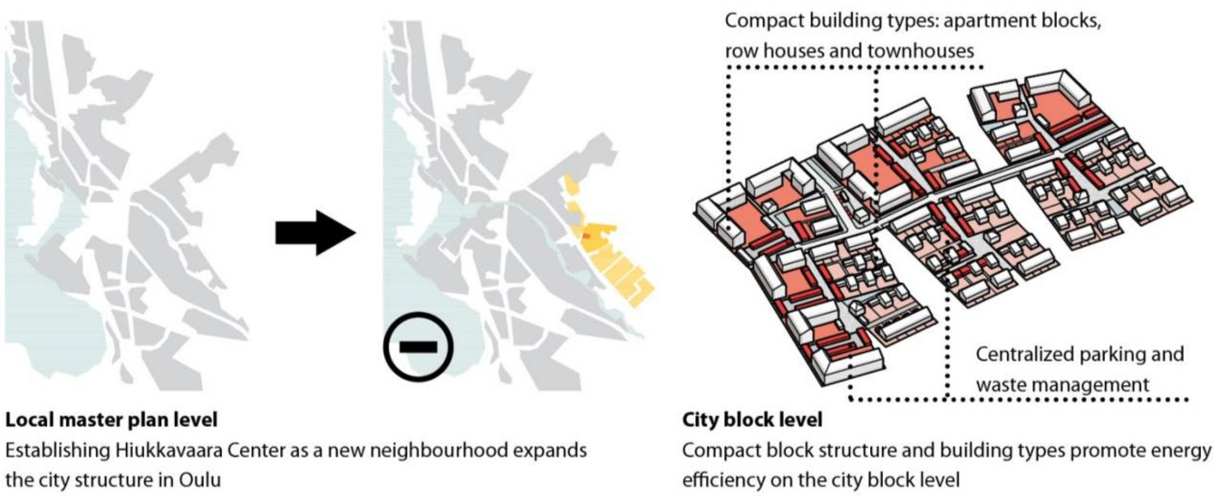

Figure 5. Measures for condensing the urban structure on local master plan and city block plan levels.

Energy production

Question 1. Assessment criteria concerning energy production by the source of the energy and the efficiency of the energy production were collected under category of Energy production. Renewable energy sources and reduction of buildings energy emissions are listed as sectoral mitigation measures in the IPCC AR5 (2014, 75–78). Co-beneficial effects are for instance improved energy security and local employment. Adverse side effects are habitat, wildlife and landscape impacts of some renewable energy sources. (IPCC 2014: 75–78.)

Questions 2 and 3. In Finland, district heating networks based on a combined production of electricity and thermal energy are highly coefficient. Wider areal energy systems such as district heating networks are outlined already in the local master plan. (Rajala et al. 2010, 139–140.) On the other hand, decentralized energy production with renewable energy sources might be more efficient measure for emissions reduction as the district heating in Oulu is produced for the most part with peat. Moreover, there is a possibility that decentralized energy systems become more beneficial in the future as energy efficient building design decreases the need for heating energy (Vehviläinen et al. 2010, 59–60; 66–67; 111). The challenge in the city block level planning is to predict which energy solutions will be applied to the city block in the future. Decentralized energy systems require space that has to be considered while planning the block structure.

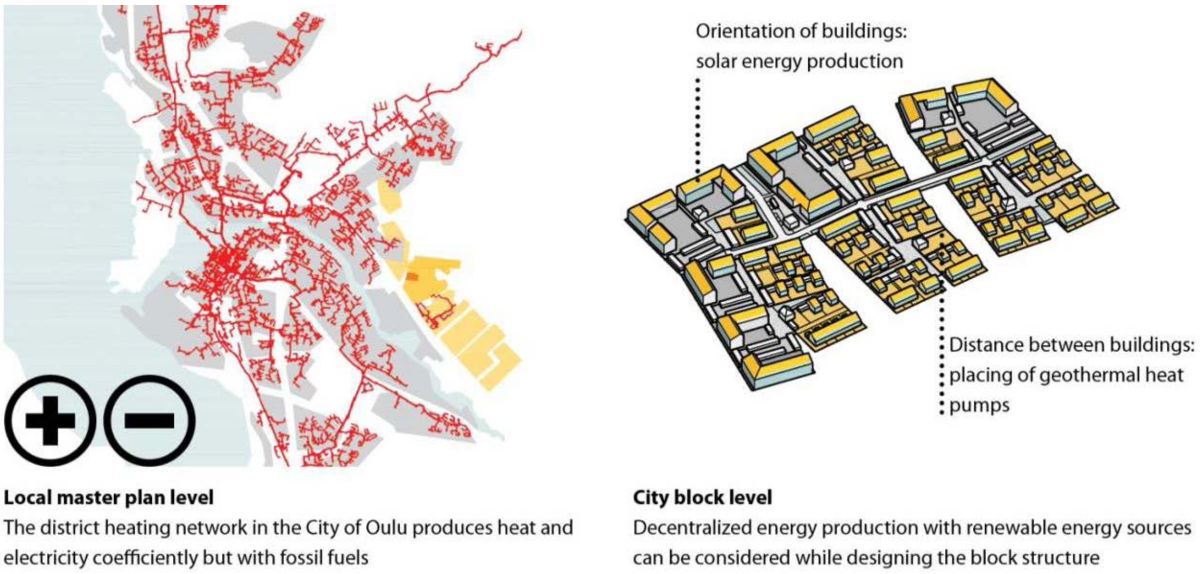

Figure 6. Measures for energy production on local master plan and city block plan levels

Protective natural and urban structures

Question 1. Assessment criteria concerning preservation of ecosystems, creating hospitable microclimates and integrating greenery to the urban structure were collected under category of Protective natural and urban structures. According to the IPCC AR5 "Reduced energy and water consumption in urban areas through greening cities and recycling water are examples of mitigation actions with adaptation benefits" (IPCC 2014: 59).

Questions 2 and 3. Comprehensive studies for preservation of natural environment and consideration to their vulnerability are typically made in the initial planning stages, when the positioning of urban structure is considered together with preserving wider green and blue networks. In Hiukkavaara, these adaptation measures have been carried out on the local master plan level. The quality of microclimate is assessed in the tools through the design of protective urban structures that shelter inhabitants from severe weather conditions. Also the area of permeable surfaces as well as green parks and roofs is used as assessment criteria. These solutions can be applied in the city block level planning as efforts to improve the quality of the living environment on the local level.

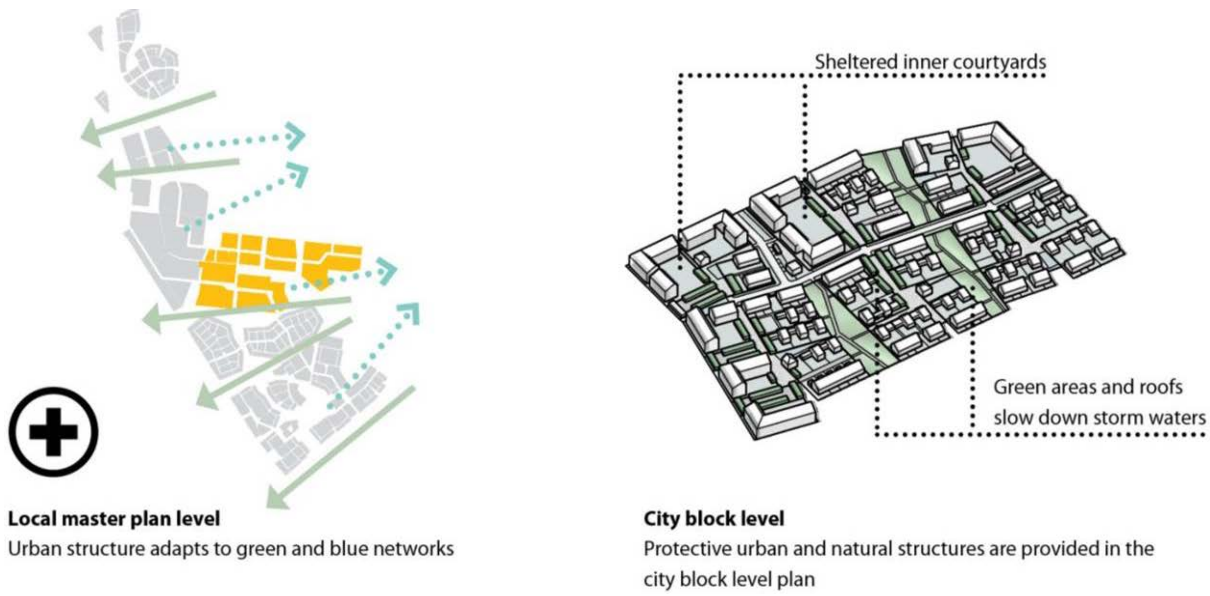

Figure 7. Measures for protective natural and urban structures on local master plan and city block plan levels

Discussion and Conclusions

In the case study, most significant contradictions emerged from integration of planning on only one level of hierarchical land use planning system with broad selection of adaptation and mitigation measures provided by the tools. Some of the measures can only be applied on levels of national land use objectives, regional planning and local master plans, whereas some can be applied only in forthcoming building phase of the area. Preston et al. (2011) present in their paper the process of robust adaptation planning that consists of four phases, 'goal-setting', 'stock-taking', 'decision-making' and 'implementation and evaluation'. The case study seemed to be lacking phases similar to 'goal-setting' and 'implementation and evaluation', which led to restricted opportunities to apply all the measures provided by the tools.

The results refer to that although there has been planning in Hiukkavaara also on local master plan level, the objectives of planning or 'goal-setting' may have been headed towards other challenges, or the objectives may have been so roughly framed that their possible shortcomings on implementation phase have not been identified. The ambitions for climate conscious planning seem not to have fully awakened until on very detailed planning level, city block planning, where the possibilities to adopt new objectives are restricted. This indicates the issue of non-flexible hierarchical land use planning system and a need for more integrated approach pointed out by Hentilä et al. (2013). Also Preston et al. (2011) reveal in their paper a similar problem on a wider context through their systematic evaluation of adaptation plans made in three developed countries under recent years. They state that the current adaptation planning is run by a top-down model, focusing on forecasting the possible consequences of climate change, but not on management of those consequences.

In the case study, 'implementation and evaluation' phase was not put into practice, as the building of the area had not yet begun. Yet some of the assessed measures, for example small-scale energy systems, require contribution and investments also from the users of the area. This challenges the hierarchical planning model, as the final users of the environment often are not yet involved in the planning process on a city block level (Kuronen et al. 2012). Moreover, the IPCC AR5 emphasizes the importance of behavioural changes in adaptation and mitigation processes (IPCC 2014).

Strategic planning, regional planning, city block level planning and building design are phases in the beginning of the lifecycle of an urban environment. The planning phases give starting points for climate change mitigation and adaptation for the users of the urban environment. An interesting question is, how the users inherit the climate conscious attitudes that have been stressed out in the planning phase, as the using phase of the urban environment is often longer that the planning phase. Although the results of this paper are based on a very narrow rendering of the problem through a single case study only, they reveal an undoubted need for further research on more lifecycle-related planning and also project formatting.

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Towards Developing Green Housing Solutions: Case Integrating Renewable Energy Solutions to Housing in Lagos, Nigeria

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Construction sector is booming in Nigeria and particularly in big cities, like Lagos. In fact, Lagos is one of the fastest growing cities in the world with a population of around 20 million and an estimated growth rate of 8 per cent per year, and there is a huge shortage of housing. In addition, there are major problems related to energy supply, which has led to reliance on diesel generators in households, services and industries.

In new residential areas, renewable energy could be integrated into housing technology. One of the main questions is how to make the solutions affordable enough for the end-users. This study will focus on analysing the future prospects of implementing renewable energy in Nigerian housing sector. The research question is two-folded: what is the current status of 'green housing' in Lagos and what is done to promote renewable energy solutions in the housing sector.

This paper is based on empirical research in Lagos, involving field visits, interviews and co-operation with Lagos government authorities. The study is still at infancy, therefore in the paper we will provide some preliminary findings and practical recommendations on how to promote 'green housing' in Lagos.

Introduction and Background

> *"Home ownership has often been regarded as a utopian aspiration for a large majority of our people; a mark of great "prosperity" and the attainment of significant "wealth". As a result, this status brought about by inequality has eluded our people decade after decade."*
>
> – *Babatunde Raji Fashola, Governor of Lagos State, July 2010 (Lagos HOMS 2014)* –

African cities have expanded rapidly in the last fifty years. The cities have tended to sprawl without much control over large metropolitan regions, and this has compounded the problems of housing and service provision. (Nwaka, 2005). Due to the rapid growth in population, the problem of providing adequate housing has long been a concern. The problem of housing, especially in urban centres, is not only restricted to quantity but to the poor quality of available housing units. Other problems are adequate and efficient supply and distribution of basic utilities and services for the city inhabitants.

The need for sustainable housing and overall urban planning is further pronounced by climate change and the adjacent need for climate change adaptation action. African cities often provide more services than rural areas, but show a shortfall in infrastructure especially on its low quality and short lifespan. Planning for climate change adaptation has to be done on long-term perspective, but it is not possible to adapt infrastructure that is not there. Hard infrastructural responses, like those for sea level rise or increased rainfall, are costly and can be maladaptive. (Niang et al. 1225).

Urban plans need to take into account uncertainty about future climates and extremes. The challenges of adaptation include inadequate resources and technical capacities, fragmentation between government departments and a lack of data on climate-related risks and vulnerabilities. In addition, existing climate models are not downscaled to the city level. (Revi 2014, 563). An example about adaptation measures related to housing is improving resilience to extreme heat. Air conditioning and mechanical cooling are often too expensive options, and can also be unavailable due to lack of electricity, so passive cooling and natural ventilation should be utilised. Green roofs have both cooling and water retaining benefits. (Ibid. 569).

Nigeria and its leading metropolitan city Lagos is a good example of challenges related to rapid urbanisation. There is a monumental deficiency in housing in Nigeria's urban centres as a result of population explosion, which is consequential of the rapid rate of urbanization occurring in the country (Olotuah, 2010). Lagos is the most populous conurbation in Nigeria and its fast, mostly unregulated growth, coupled with the challenges of its fragmented geography, has resulted in large expanses of urban slums and spontaneous settlements. According to an estimate by Frost & Sullivan, 70 per cent of Lagos population will live in informal settlements by 2030 (James, 2014.)

Nigeria's vision 20-20-20 is to be one of the world's 20 largest economies: consolidate its leadership in Africa and establish itself as a significant player in the global economic and political arena. Government's efforts in meeting the needs of the people have continued to be inhibited. The number of housing units provided by the government, developers or individuals have been insignificantly small relative to housing problem in Nigeria. Lack of access to good or decent housing has continued to be a major challenge (Sunday, 2012). In Lagos, the high costs of land and uncontrolled housing prices have led to a situation, where even middle-class people cannot find affordable housing. High prices further increase speculation in the housing sector, as the rich invest in housing.

The approach to housing policy in Nigeria has tended to oscillate between the 'welfare mixed economy' and the 'free market model'. Issues of desirable public housing form, materials and methods of construction, best location for public housing schemes and effective utilization, management and maintenance of public housing units, are still prospective areas of research. Particularly in Lagos metropolitan area, there is a need for both public and private developers to facilitate the provision of housing units in sufficient numbers and at reasonable costs (Idosi, 2008). Hence, a comprehensive public and private approach to the housing problem is required to make a progress (Ademiluyi and Raji, 2008).

Urban development and restoration should be a major concern of government in order to reduce the environmental stress experienced in the urban centres and to prepare for impacts of climate change. Most Nigerian urban centres require extensive urban renewal programs. One major challenge in Nigeria is the provision of electricity. At the moment, the centralized electricity production capacity is far behind the energy needs. This has led to a situation, where both individuals and businesses have to rely on diesel generators for energy supply. The use of diesel generators is both costly and causes serious environmental and health impacts. According to the Lagos State Electricity Board, there is at least one diesel generator in every property in the state. The total number of diesel generators in the country is around 70 million (Ogunbiyi, 2014).

In this paper our focus is on analysing the current situation of 'green housing' in Lagos and what is actually done to promote the use of renewable energy solutions in the housing sector. The specific level of analysis is on the gated-communities which are increasing in Lagos as well as in other African mega-cities. We also use other recent green construction as an example.

Green Housing and Gated Communities

Gated communities (GCs) have increasingly become a new development trend in the real estate markets in many African countries. Gated communities mean housing developments that restrict public access, through the use of gates, barriers, walls and fences or through the employment of security staff or CCTV systems to monitor access (Ilesanmi, 2012). Gated communities can include both enclosed neighbourhoods and security villages. Enclosed neighbourhoods refer to existing neighbourhoods that have controlled access through gates or booms across existing roads. Security villages refer to private developments where the entire area is developed by a (private) developer (Landman, 2000).

It is expected that the amount of constructing new GCs will increase partly due to the pervading state of insecurity in Lagos. These new residential areas can occur in both new suburban developments and older inner city areas. The developers of GCs market them as safer, friendlier and more economically stable traditional urban or even suburban neighbourhoods; gated communities reflect an urban entity that is physically and often socially and economically differentiated from the surrounding urban environment.

The question of environmental and social sustainability of gated communities have been raised up in the previous research (Ilesanmi, 2012; Ajibola et al., 2011). The UN Habitat's Programme for Sustainable Cities define sustainable city 'as a city where achievements in social, economic and physical development are made to last.'

Renewable energy technologies, apart from being sustainable and inexhaustible, can be set up in small units and is therefore suitable for community managements and ownership. A sustainable housing is measured in terms of resource use and management e.g. water, energy, waste/recycling as well as building design or construction practices. Sustainable houses have minimal adverse impacts on the built and natural environment. The use of locally made materials and appropriate technology in housing delivery has been the aspiration and focus of many housing fair and exhibition (Ademiluyi and Raji, 2008).

Material and Methods

This paper is based on mixture of data collected from various sources. The primary data is based on empirical qualitative data and reviewing the existing studies on urban sustainable housing in Nigeria. Three field visits were made in Lagos between December 2013 and March 2014. We interviewed several representatives from various organizations; private companies, public institutions and research institutions. More information about the interviewees is available at Appendix 1. In March 2014 one of the writers co-organized a workshop on sustainable housing in Lagos – also discussions and notes from this workshop are used for this paper. The workshop was part of a TEKES (The Finnish Funding Agency for Innovation) funded Connect project aiming at creating and modelling of networks to new markets for Finnish renewable energy SMEs.

The aim of the workshop was to create common understanding about the current situation and development interests related to sustainable urban growth through renewable energy solutions in the housing sector in Lagos. In total there were 37 workshop participants, including representatives from Lagos State Ministry of Environment, Ministry of Rural Development, Ministry of Works and Infrastructure, Lagos State Electricity Board, NAQE LASG, Bank of Industry/UNDP Access to Renewable Energy Project, Rubitech Ltd., Midori Environmental Solutions, Green Architects, NASCON PLC, B9 Technologies Ltd, Lautech Ogbomoso, Ateng and Company Nig. Ltd, Bistar Ltd, Babcock University and University of Lagos.

The Lagos State Ministry of Environment organized in March 2014 the 6th Lagos State Climate Change Summit, where also housing issues were discussed. One of the Finnish writers was also invited to the summit as a speaker. To complement the interviews and other information gathered on fieldtrips, and to deepen our understanding, we used also secondary data, such as newspaper articles and previous studies.

Results: Green Housing in Lagos

Lack of access to modern energy is a major problem in Nigeria – similarly as in many other African countries; only 40 percent of households in Nigeria are connected to the national grid. Besides inadequate energy generation, there is high energy loss due to the physical deterioration of the transmission and distribution facilities. Other problems of the power sector include manpower constraints and inadequate support facilities, the high costs of electricity production, inadequate basic industries to service the power sector, poor billing systems, poor settlements of bills by consumers and low available capacity (Sambo, 2009).

Lagos, by the UN standards, has attained the megacity status, with the attendant challenges of living up to that titanic position: it lacks the marching infrastructural facilities. The population pressure has been heightened by inadequate housing provision for the continuous streams of immigrants. (Ilesanmi, 2009). State government provides new housing (200 new houses built each month), and housing companies and individuals are also building for themselves. Nevertheless, this is not nearly enough for the demand. Besides housing problems, Lagos is facing several environmental problems, such as soil, air and water pollution; dumping of toxic industrial waste, ineffective solid waste management, insufficient sanitary infrastructure, and limited access to basic infrastructure and municipal services.

Lagos State Government aims to improve the situation. Policies are under development and put to place to create an enabling environment for green construction. Attention has also been directed towards the quality of construction in recent years. There are guidelines and regulations already in place, but effective implementation is a challenge. Regulations are on different levels: federal, state and local, and there are differences in regulations between states. For all construction in Lagos, approval from the state government and sign-off from different Ministries (for sewage, roads, electricity installation etc.) are needed. In addition to architectural drawings, for example, electricity installation plan is required. Nevertheless, no regulations for energy efficiency, renewable energy use, or other green construction elements are yet in place. One challenge is also information sharing between different organizations working on energy and environment. (FUAS, 2014).

State Housing Policy exists in Lagos, but it is currently not used to promote renewables. There are no incentives to use renewable energy in housing, and investments to renewable energy are perceived as expensive and risky. For the consumer side, it is challenging to explain the rationality of long payback time as the banking system with high interest rates does not support long-term investment. Solar systems are mainly used by real estate companies. (FUAS, 2014).

Policies alone are not sufficient, also concrete actions need to the put in place. Currently, there are few initiatives of green construction in Lagos. For example, Lagos authorities have set up a specific Lagos Mega City Project. It aims to be a response to the chaotic nature of urban development in Lagos State. The mega city covers the whole Lagos State and four local government areas in the neighbouring Ogun State: Ado-Odo/ota, Ifo, Obafemi Owode and Sagamu. The project attempts to address various developmental problems including power generation, fire prevention, security, and geographical restructuring to leave ample parks and open gardens (Ogunsote et al., 2012).

The Lagos Home Ownership Mortgage Scheme has also been established by the Lagos State Government to improve access to affordable housing. The Lagos HOMS provides access to housing through a mortgage scheme for houses in four areas in Lagos. The houses are distributed through a lottery with an interest rate of 9,5% in April 2014 (Lagos HOMS, 2014). The Ministry of Housing has developed prototype housing with 1140 units on the block at the beginning of 2014 and additional 3156 units to be on the market around middle of 2014. The prototype housing consists of four-storey blocks of flats with one, two and three bedroom units. Environmental concerns are taken into account in the positioning of houses for: natural lightning, minimization of heat radiation, minimization of impacts of driving rain, and maximization of wind direction. The housing also introduces vertical development that conserves land, while the buildings are well spaced out to reduce congestion and heat generation. The roofs are designed to collect rain water for use in washing and plant watering. There are also plans for including solar water heating and Independent Power Production (IPP) plants working on natural gas for electricity production. The IPPs would reduce the current reliance on diesel generators (Jeje, 2014).

One concrete example of green housing is the construction of Eko Atlantic City. Eko Atlantic City has been planned as a home to about 250,000 residents and workplaces will add additional 150,000 people. The Eko Atlantic City is spread over well-planned districts – Ocean Front, Harbour Lights, Business District, Eko Drive, Marina District and the Avenues area. Energy for the new area will be provided through Independent Power Production plants utilizing natural gas, and the area has its own clean water and waste water treatment systems (Eko Atlantic 2014). An interesting issue from the environmental point of view is, however, that the whole Eko Atlantic City is built on reclaimed land of 1000 ha, using approximately 90 million m^3 meters of sand dredged offshore at the Lagos State shoreline (Royal Haskoning 2012, 3.)

The first environmentally certified commercial building in Lagos, the Heritage Place, is under construction. The building is comprised of 15,736 square meters of office space over eight floors. Heritage Place is LEED certified for both design and construction. The building is expected to achieve between 30–40 per cent reduction in energy use compared to average buildings in Lagos. Key features in the building include rain water harvesting, condensate recovery from the cooling units, automatic presence detectors and high-efficiency lighting, building orientation to maximize natural light and ventilation and to minimize solar exposure, and high efficiency glazing and external thermal envelope (Heritage Place 2014).

A survey on sustainable housing in Lagos was conducted by Adebamowo (2011, 171). The survey involved 60 key respondents in the housing sector from mortgage bankers, real estate financial institution, construction companies and building consultants. The questions concerned: the state of housing in Lagos, the practice of sustainable housing design and development, the identification of the factors affecting the delivery of housing in Lagos, the performance of the housing market over the past 3 years and the impact of economic downturn on house prices in Lagos. In a scale of 0 to 5 (0 very poor - 5 excellent) the respondents' average for the state of housing in Lagos was around 1.2, which can be described as poor. With regard to sustainable housing, the majority of respondents viewed the concept of sustainability as foreign probably because of lack of understanding on one hand and the resolve to address more pressing needs on the other hand.

Gated Communities in Lagos

The number of gated communities is increasing in Lagos, but Ilesanmi (2012a) assumes that gating is yet to generate debate regarding its spatial, social, economic or political implications in the context of Lagos. He emphasizes that it is a necessity to develop tools to better analyse gating, for instance from the perspectives of impacts, sustainability, and macro-infrastructural needs. A study by Ilensamni (2012b) examined the quality of housing in six different types of neighbourhoods in Lagos. Of these areas only private Goshen Estate, a gated community in Lekki achieved favourable points on the quality of neighbourhood infrastructure and housing. However, as the residents of the exclusive, low-density residential estate are predominantly high-income, it cannot really be used as a model for sustainable housing development.

From the point of view of green housing, gated communities provide good opportunities to utilize sustainable technologies. For instance, a renewable energy solution can be provided to serve a number of houses instead of single households. The up-scaling of solutions can help in finding cost-effective solutions. In Nigeria, the emphasis has so far been mainly on solar photovoltaic, but also bioenergy might prove useful in communities. While waste management is still lacking, small-scale bioenergy solutions based on biodegradable waste, including human wastes, could help in alleviating both waste and energy shortage problems. As discussed in the workshop organized in Lagos, one of the main challenges is still finding locally adapted, affordable technologies. (Connect workshop 2014).

Public awareness of environmental issues has increased in Nigeria. At the national level, the aim is that by 2025 40 percent of power will be generated by alternative energy sources. There are challenges for the expansion of renewable technologies. So far, experiences particularly of solar products have not been so positive. The reasons for this lie in poor planning of projects, quality of technology, overloading of systems, and lack of maintenance. Capacity building is needed at all levels to enhance especially planning and procurement skills. There are also training needs related to maintenance. At the moment, renewable energy companies often train their own maintenance staff themselves. As the use of renewable energy increases, the training should be more widely available, for instance, at universities or polytechnics. (Gada 2013).

In the housing sector, property owners and clients are seeking commercial building that meets acceptable environmental and health levels. Nevertheless, there is lack of institutional structures promoting green building: awareness on the part of clients, tenants, professionals in the built environment and other stake holders: professional capacity to incorporate green building issues and opportunities and: financial resources to undertake green building construction and upgrades. (Nwokoro and Onukwube, 2011).

Discussion and Conclusions

The aim of this paper was to analyse what is the current status of green housing in Lagos and what is actually done to promote renewable energy solutions in the housing sector. Although this paper was based on empirical field work in Lagos and rich discussions with various local stakeholders from private, governmental and research field, it became obvious that it is difficult to get a clear picture of the situation of green housing in Lagos.

Construction sector and more particularly, housing, is seen widely as an area where there is a need for alternative energy solutions. Current production of electricity is based on diesel generators, which is unsustainable both from environmental and economic point of view. There is a shortage of housing in Lagos, and the construction sector is growing fast. Alternative solutions for energy production are considered attractive and there is a strong interest in existing renewable energy solutions, such as solar water heating and solar PV, which could be utilized also at residential houses.

Nevertheless, the adoption of green technologies is not progressing fast. Hence, the question remains; how to promote the use of green technologies? Based on our research, it can be concluded that policies favouring green energy must be developed; not only good policy frame but also proper implementation. Government policy can be seen as a one of the key factors, and the evidence from other African countries supports this. In some other African countries, the state has taken a stronger role to promote the adaptation of green technologies. For example, in Kenya it is mandatory that new houses and buildings have solar water heating systems that heat 60 percent of water, if the daily consumption is more than 100 litres (Energy Regulatory Commission, 2014). This kind of regulation advances the use of solar energy, and promotes technology development. Besides this, there are regulations concerning increasing the amount of certified technicians. Perhaps Nigeria, and particularly Lagos State Government, could consider of launching similar kinds of regulations. At the moment, for example, solar water heating is not common, although the technology is relatively simple and cost-effective.

A study by Ross et al. (2010) analysed nine sustainable housing projects in South Africa and other developing countries through a set of 49 indicators. The results were encouraging especially in the fact that the projects experimented with little known solutions and technologies, like alternative sanitation systems. However, also several barriers for implementation were identified, including low levels of user support and acceptability, high initial costs of certain sustainable measures, the non-provision of services that might equip communities to live sustainably beyond the construction stage, political agendas that put more emphasis on the number of houses built than their sustainability, and not prioritizing sustainable measures from the outset of projects. (Ross et al. 2010, 447.) A particular problem identified with solar PV was the high price. In addition, renewable energy was not always taken into account at the planning stage, which made its utilisation difficult later. (Ibid. 443).

Another key factor in the adoption of green technologies is that quality standards need to be followed. Standardization organizations and Energy Commission for Nigeria need to monitor the quality of the products better. Through this also consumers will have more positive views on renewable energy products, and the investment on new technologies becomes more attractive. Another issue to consider is tax incentives and funding schemes; how effective tools they are to encourage the adoption of renewable energy solutions. For instance, banks could support more long-term investments on renewables; at the moment interest rates in Nigeria are so high that they often prevent this type of investments.

In addition to factors listed above, awareness raising and capacity building are needed at all levels from planners and architects to consumers. Concerning consumers, they might not understand the benefit of renewable energy and therefore, not demand it. Capacity building is needed for the correct procurement, installation and maintenance of technologies. As evidenced at the housing workshop organized in Lagos, and throughout the Connect research project, there is interest in international cooperation and networking to support development of sustainable, localized solutions. One way forward could be joint research projects that would bring together both academics, government organizations, companies and other key actors to identify key challenges and to co-create, pilot and test solutions.

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Appendix 1. List of Informant Organizations

Organization	**Date**
Arthur Energy Technology	12.12.2013
Bank of Industry / UNDP Access to Renewable Energy Project	4.12.2013
BAS Associates Consulting / Rubitec Nigeria Limited	2.12.2013
B9 Technologies	5.12.2013
Blue Ocean Nigeria	7.12.2013
Erstegraceland Ltd.	11.12.2013
GreenPower Overseas Limited	12.12.2013
Hartford Green Consulting	6.12.2013
Konsadem Associates Ltd	6.12.2013
Ladoke Akintola University of Technology	9.12.2013
Lagos Chamber of Commerce and Industry	3.12.2013
Lagos State Ministry of Energy and Mineral Resources	3.12.2013
Lagos State Ministry of Rural Development	3.12.2013
Lagos State Ministry of the Environment	9.12.2013
Lagos State Waste Management Authority, LAWMA	11.12.2013
Midori Environmental Solutions	10.12.2013
Nigerian Conservation Foundation	4.12.2013
Nimcom Link Resources Ltd.	3.12.2013
Wiseab Nigeria Ltd	3.12.2013

Strategic Planning and Epistemology of Change: Probing the Fitness of Urban and Planning Systems with Resilient Spatial Strategies

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The aim of this paper is to question the fitness of our state-of-the-art urban planning and urban systems to adapt to continuous changes and disturbances in operating environment. We argue that in an attempt to help cities adapt to uncertain futures, strategic planning should be better informed by the epistemology of complex adaptive systems and better recognise recursive emergent processes between urban metabolism and morphology.

Introduction and Background

Climate change has been addressed in political and economic discourse as one of the major threats of our times to the future of societies, the mitigating and adaption strategies of which require unforeseen measures on a global scale and the impacts of which are highly unpredictable. The focus on urban environments is particularly intriguing since cities are economic and socio-cultural concentrations where any serious disruption has the power to affect large numbers of people and resources thereby disturbing the functioning of the urban system. The volume of climate change research and policies concerned with implications on institutional planning, governance and strategies of adaptation has been increasing in the last decade. Alongside policy level adaptation capacity we also need to focus on the capacity of physical and socio-spatial environments to withstand major changes (see Seto *et al.* 2014).

In this paper we question the fitness of our state-of-the-art urban planning and urban systems to adapt to continuous changes and disturbances. Urban planning and design has a key role not only in spatialising climate change strategies but also in outlining the spatial conditions for future development. Therefore spatial planners should be more acutely aware of the possible impacts and processes that planning contributes to catalyse or inhibit. More precisely, in urban planning we should focus on *systemic* impacts and the very inter-relatedness of urban activities. Our study contributes to debates about an ontological turn in planning knowledge and the claim to revise our planning system with the knowledge of complex systems and resilience theories (e.g. De Roo *et al.* 2012).

Complexity theories have had an increasing impact on the development of urban theories since the 1990´s (e.g. Batty & Longley 1998, Portugali 2011, Allen 2012). According to them cities can be conceived as complex physical, socio-economic and ecological systems, the multiple equilibria of which are constantly under threat. Due to the very interdependence of urban agencies the impacts of changes are unpredictable and non-manageable by hierarchical top-down planning strategies. Resilience and complexity can be seen as relative and complementary terms (Wilkinson 2011, Portugali 2011). Resilient strategies emphasise the inevitability and early discovery of failure and a quick recovery from shocks (Snowden 2011). Although resilience has become a prominent metaphor in transition studies, in practice, examples of its operationalisation fall short.

We aim to focus on self-organising criticality embedded in the co-evolving complex systems of cities, and pay special attention to physical agency and the robustness of spatial practices. A systemic approach allows us to deal with urban change as recursive processes, which build on linkages between urban agents and path dependencies between planning interventions and spatial outcomes. Therefore, we need to be able to identify the critical areas within the urban system and to pursue tactics and implementation measures within actual spatial practices in order to prevent the system from malfunctioning or collapsing.

The objective of the study

The paper addresses the question of systemic adaptability to disturbance at various levels of observation. We assert that major risks to adaptation are due to epistemological and structural gaps in planning and urban environment. We claim that the problem lies in the inertia and resistance of organisational and structural agencies: the prevailing ideals of the modernist planning tradition, in the first instance, and the sheer material permanence of modernist urban heritage that adaptive strategies have to come in terms with. Our focus is on urban systems and the planning instruments of cities[52], and our aim is to explore their structural, morphological and configurational properties and their capacity to adapt to constant and sudden changes.

It can be argued that a great deal of potential as to how cities cope with disruptions in terms of adaptation to change and transformation can be traced to *urban morphological properties*, that is, the spatial and configurational properties. The question is how adaptable our present built environment is in terms of technological solutions and configuration to reorganise and enable phase transitions. We suggest that a new synthesising framework needs to be elaborated to better conceptualise urban dynamics, and that complex systems is a prominent approach to inform planning both theoretically and operationally. More precisely, understanding the physical dynamics and the development of planning tools that can grasp the dynamic character of the environment are of crucial importance in bridging the gap between strategic and operational planning.

At a conceptual level, we question the competence of normative policies to deal with emergent, "bottom-up" impulses. This is mainly due to the hierarchical top-down order implicit in our planning system, which makes it inflexible to respond, for instance, to sudden development initiatives that require quick reaction (Wilkinson 2011, Mäntysalo *et al.* 2014). We will reflect on the adaptation capacity of urban practices using an approach informed by complex adaptive systems and the concept of resilience as a metaphorical tool to help us reveal weak areas in western planning practices. In what follows we claim that a gap is embedded in the theoretical basis of contemporary planning adopted by the planning system. Our planning system is true to the top-down *hierarchical* and *rational comprehensive* tradition echoing the 1960's system-rational planning approach, and its spatial basis owes much to the location theoretical thinking of the same era. In the political discourse and strategic planning the significance of physicality is generally undermined. In strategic planning urban problems have been turned primarily into problems of governance, power and communication, whereas operational planning has embraced technological solutions. Meanwhile the essence of physical space has gone unnoticed. Regardless of the quality of governance processes, or the emerging digitalisation of cities, it is the very geometrical properties of cities that continue to have

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[52] The main focus of our observation is the Finnish planning system. By planning system we mean the whole legislative and organisatory apparatus available to control land-use, ranging from strategic to operative planning, regulation and jurisdiction at various scale levels. However, the critique also applies generally to the modernist Western urban planning tradition, which has only recently sought after methods that contest the rationalistic top-down planning paradigm.

an impact on social and economic life in cities, influencing their quality and shape directly and indirectly (Batty 2013a).

Theoretical framework: complex adaptive systems and resilience

The systems approach has already been applied as a strategic framework in planning research and climate change studies (e.g. da Silva *et al.* 2012). Implicit in the systems approach, resilience has been addressed as the new perspective in conceptualising and measuring the adaptive and transitory dynamics of environmental and social systems (Folke 2006). Only recently have planning theories been challenged to better recognise social-ecological resilience (Wilkinson 2011). Confusion persists, however, about the operationalisation of the concepts and their pragmatic applications. More precisely, this is the case in regard to spatial implications.

As the traditional systems approach stressed irreducibility and dynamic yet predictable interactions and feedback mechanisms between its parts, the "new" systems reading of *complex adaptive systems* addresses the dynamics of change on the basis of non-linear rather than causal relations, complex/chaotic behaviour emerging from simple initial conditions, self-organisation, co-evolution, cross-scales and adaptation (see e.g. Gleick 1989, Portugali 2011, Allen 2012, Holland 1998). Understanding the principles of complex adaptive systems is essential as it lays the epistemological and operational foundation for resilience conceived as a counterpart of complexity.

Resilient thinking has replaced sustainability in much of planning discourse. It implies a turn of the strategic focus from resistance and preservation to recovery and evolution (Folke 2006, Snowden 2011), bearing a positive connotation in regard to crisis (McEnvoy *et al.* 2013). It can be regarded as an alternative to a more common 'predict-and-prevent' approach (Wardekker *et al.* 2009). The body of resilience studies is constantly growing in many disciplines and the concept is proliferating fast to fields concerned with strategic planning and foresight building. Yet there are identifiable gaps between policy-making and implementation as well as between disciplines. Despite much research done on socio-ecological and spatial resilience (Cumming 2011), approaches to conceptualise and operationalise the resilience of urban morphology are few. Some common ground, however, can be found between resilience studies and developed morphological studies.

Definitions of resilience

The concept of resilience emerged from ecology in the 1960s and 1970s, coined by Holling (1973). Theoretically, resilience is divided into engineering and (social-)ecological approaches (Folke *et al.* 2010). A more generic distinction is made regarding the technological and metaphorical use of the term (Wardekker *et al.* 2009). Whereas the engineering approach emphasises the aspect of maintaining functionality and the system's quick return to a stable state, the ecological approach is interested in the limits of systemic functionality and adaptation to new processes by "staying in the game" (Kärrholm *et al* 2012, 2). Departing from robust failure-proof thinking, resilient strategies emphasise the inevitability and early discovery of failures and a quick recovery from shocks (Snowden 2011). A commonly used definition for resilience is "the capacity of a system to absorb disturbance and reorganise while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks" (Folke *et al.* 2010). In a systemic sense three characteristics of (social-ecological) resilience are identified: first, the amount of change the system can tolerate and still retain the same controls on function and structure; second, the degree to which the system is capable of self-(re)organisation to accommodate external changes.; third, the ability to build and increase the capacity for learning and adaptation (Wardekker *et al.* 2009). Systemic phase transitions and transformability in cross-scale relations are essential to the ecologic resilience view (Folke *et al.* 2010).

Our main interest is to observe the fitness of our current urban and planning systems to reorganise in – or resist – alternative paths and unpredictable evolutionary trajectories. Therefore we should be able to trace the critical systemic components adding to a functioning of a system, that is, to identify the co-evolutionary and mutually reinforcing agents and feedbacks/path dependencies at various scales that are essential to a viable system.

Increasing resilience in planning: understanding urban networks

The first implication of resilience is the capacity of the system to recover from shocks and the capacity to withstand disturbance. Engineering resilience measures the efficiency of the system to maintain its functionality and retain the required fluency of service when distracted. The notion of a "percolation threshold" (Batty 2013b) – the critical point where the disruption becomes total in a system – leads us to consider structural properties more closely, that is, the interdependent linkages between urban metabolism and morphology, density and connections. Instead of representing spatial entities as absolute and hierarchical, we should focus more on identifying networks – social as well as ecological, their links and nodes, at different scales – as they constitute the essential property of contemporary urbanity and complex systems.Michael Batty takes the notion of the importance of networks as the basis for new strategic thinking, economic growth and resilience as networks can inform us about generic systemic relations in cities and how cities evolve relative to one other. A complex system is bound together with multiple inter-linkages and feedback mechanisms, which makes it fragile. (2013b) For example, a transportation network as a system consists of an infrastructure network, vehicles and users, wherein resilience refers to the reliability of the system's functioning. The very connectedness of the network is a crucial measure, which allows bypassing and detours if the primary routes are blocked. However, a hierarchically distributed road network and settlement patterns (based on a tree-like topology favoured by modernist traffic planning) implies vulnerability to disturbances. There are various centrality based assessment tools and monitoring devices using real time large data sets to measure potential flows in urban networks and, accordingly, to assess the severity of discrete disturbances to the network.

The notion of hierarchical networks as an organising pattern leads us to observe the second interpretation of resilience as the capacity to withstand shocks in a long run through reorganisation (*phase transition*). Hence, it is not primarily an issue of traffic flows *per se.* More importantly, flows of people generate socio-economic agglomeration and hence the potential emergence of socio-spatial diversity as a function of accessibility. Diversity and redundancy are regarded as the prerequisite properties for continuous evolution (Kauffman 2008). Modernist urban planning has favoured mono-functional techno-structural solutions and the separation of activities in organising the city efficiently as a mechanistically functioning simple system. Presumably efficiency is still a desired property, but more contemporary goals are likely to be urban morphological properties that enhance interactions, enabling self-organisation and constant evolution. Therefore in regard to evolutionary resilience, we can ask if it is a reasonable goal to "retain essentially the same function, structure, identity, and feedbacks" as the definition of resilience suggests (Folke et al. 2010).More precisely, as regards physical activities, we need to add the emergence of tight linkages between physical properties and the use of networks. Connectedness may also be seen as an interlocking mechanism, where multiple lock-ins make the system hard to break. Due to the bundled nature of materiality, competence and meaning in social-spatial practices (Shove *et al.* 2012), networked practices resist change. Yet at the same time they are vulnerable in crisis situations. Drawing on the bundled nature, Shove *et al.* stress the emergence of bottom-up sustainable practices rather than top-down policies (ibid.), laying claim to emergent bundles of social practices that may lead to sustainable trajectories. Therefore urban planning should focus on creating the conditions for the rearrangement of current practices. Subsequently, this would entail identifying the most probable behavioural patterns rather than expecting the idealised behaviour of agents.

By using a framework of network urbanism we are able to conceptualise inter-linkages between urban networks. We can focus on interactions between infrastructure and physical urban networks, locations of activities and actors' transactions (Dupuy 2008). For this it is essential to ask: what implications emerge from these essential dynamics of resilience to urban systems? Using Holling's adaptive cycles the implications for urban systems can be simplified: The system needs the capacity to reorganise to maintain its functionality, hence the more connected the nodes in the networks and overlapping the activities will increase potential flows, interaction between agents, innovations and productivity. After a stabilised, conservation state the system needs minor disturbances to avoid stagnation for the cycle to resume reorganising. It is noteworthy, however, that in the case of a severe disruption the system will collapse. The evolutionary cycle is thus non-linear but proceeds in cyclical phase transitions, oscillating between chaos and order. Resilience is the objective property of systems to avoid ~~a~~ collapse before severe singular shocks or multiplying effects caused by many simultaneous disturbances from different sources. A system's overall stability depends on whether its parts or sub-systems are in a stable or unstable state; a system may seem to be in equilibrium but the state may easily be disturbed depending on the robustness of its constituent parts (equilibrium equivalent to resilience, not referring to stability but to instability). In planning, efforts aiming to eliminate single causes would only prevent agents from reorganising to adjust their behaviour to a new situation. In urban systems there are multiple co-evolving and reorganising processes in progress simultaneously.

It is easy to see that due to the high density of cities and all their interlocking networks (low 'percolation threshold'), an urban system is potentially at risk of a major catastrophe. However, an urban system could be transformed to better withstand shocks, not by separating activities so as to increase the autonomy of its parts, but on the contrary, by increasing interconnections to allow alternative routes and feedbacks for action (in terms of emergency, alternative routes for escape, flooding; in the continuous urban process, alternative routes for spontaneous interactions and economic reorganisation). Rather than aiming to control the whole with a comprehensive master-plan, incremental steps make it possible to adapt to sudden changes. Yet this approach requires an overall strategy, a vision and outlined values as goals, against which the ad-hoc interventions are assessed. The question remains to be solved - to what extent and by what means to intervene in an existing status-quo.

The adaptive and evolutionary turn in planning: bridging the gaps

Our first focus is the argument of an assumed gap between science and planning practice. How should we improve the consistency between the knowledge of scientific research and planning praxis – the interests of which are regarded as either theoretical or pragmatic – as the usability of the former for the latter is generally questioned? We start by first claiming that the relations between the domains of science/policy/practice are entangled so that reduction to a simple relational rule is not an option. Second, that the gap between strategic and operational planning most definitely exists. Third and most importantly, in bridging this gap, we suggest that understanding contemporary developments in the scientific knowledge creation of cities can actually serve as a key. Many researchers have suggested that there are knowledge gaps between strategic and operational planning; that strategies pertain in established methods which do not reflect the real requirements of spatial development (e.g. Naess *et al.* 2013). This is a particularly crucial notion when dealing with adaptive and sustainable strategies, the formulation and operationalisation of which are bound to the conceptualisation of the problem, whether from an idealistic or realistic perspective. It can be argued that many of the recognised knowledge gaps derive from the theoretical and methodological assumptions that do not suit well to designing contemporary cities - and may actually be harmful when aiming at adaptation and resilience.

Planning is about building bridges between what is 'real' and what is possible, and between the analytical and normative (e.g. Pakarinen 2010). The contemporary planning paradigm has not progressed very far from the rational-comprehensive ideals of the past century (Joutsiniemi 2010). For instance, the discussion of the need for an "evolutionary turn" in planning (Bertolini 2010), or generally the ever-growing literature on complexity in planning (De Roo & Silva 2010; De Roo *et al.* 2012) are clear implications of this. The foundations of rational planning theory were laid in the 1960's systemic turn, the aim of which was to define urban planning in scientific rather than artistic terms (see Faludi 1973). By asserting that planning should be based on precise and validated knowledge of the operating environment and by determining the procedural justification it seemed to emphasise the value of the process more than its spatial outcome. To counteract this in the 1980's communicative pragmatism emerged to oppose the over-theorising of planning. Nevertheless, the co-operative and participatory planning approach did not succeed in bridging the gap between process and physical/spatial outcome. In planning positive/quantitative/scientific and hermeneutic/qualitative/social approaches have taken turns. We have come to an age where we need both scientific "hard" knowledge and "soft" social-cultural understanding; knowledge of the process as well as the substance and new theoretical and methodological linkages between them. Here complexity comes into the picture as a bridging theory (De Roo *et al.* 2012). Analysis and synthesis help visualise the hidden properties underlying environmental processes, after which follows the visionary, creative process of design, which is intentional, normative and necessarily a reduction of all possible solutions. A significant part of epistemological change concerns knowledge creation so as to better inform planning and decision-making on the 'real', relative and relational conditions, rather than the ideal or assumed conditions of the environment and people's behaviour.

Hierarchical planning and recursive interaction

Jane Jacobs stated back in the 1960's that without constant innovation processes and sufficient diversity to catalyse innovations cities would stagnate. Fifty years later, following Jacobs, Bettencourt et al. (2007, 7306) address the growth mechanism by stating: "*Open-ended wealth and knowledge creation require the pace of life to increase with organization size and for individuals and institutions to adapt at a continually accelerating rate to avoid stagnation or potential crises.*" In this respect, resilience entails "creative destruction", as its formal description implies a continuous cycle of phases of innovation-revolution and conservation-stabilisation (Holling 1973). In Holling's theory, the cyclical interaction implies a tense relationship between scales. The emergence of impacts from micro-scale to macro-scale represents bottom-up revolutionary stimuli to the system, whereas the macro-scale can be seen to act as a stabilising sphere, possessing inertia and resisting change. Although urban *metabolism* and innovation cycles take up an accelerating rate (in contrast to biological systems: Bettencourt et al. 2007), it seems that urban *morphology* is more likely to follow the pace of biology with a slower renewal rate subject to inertia and memory embedded in materiality. By comparison, a planning system can be seen to align with these dynamics with the exception that it emphasises top-down, from macro- to micro-scale implementation, rather than a continuous adaptive cycle between scale levels. Therefore, from the viewpoint of change, resistance and longer time-horizons are embedded in the physical and organisational structures of urban and planning systems. How much self-/reorganisation they allow is a function of their structural and configurational properties. In other words, a planning system lacks the ability to absorb and benefit from surprises and sudden changes in the planning environment (Wilkinson 2011). The objective of urban regulation has been to minimise negative externalities by separating activities considered to cause disturbance to each other. Disturbance to a large extent or at many simultaneous levels is undoubtedly a threat to the system, but nevertheless, from the perspective of evolutionary resilience, it is vital and can be a potential source of innovation (ibid., Folke 2006, Folke *et al.* 2010).

Rethinking modernist urban planning and its capability of self-organisation

Despite the recent findings in natural sciences, our institutional planning system has retained its naïve assumption of predictability. If the deterministic systems of no more than a handful of variables are capable of behaving in an unpredictable manner, how can a planner rely on such a vague and uncertain setting? The most urgent shift of focus, therefore, is to build tools not for prediction, but for tracing the sources of un-prediction.

We observe the modernist planning principles and urban morphology and assess their self-organising capacity. Since the 1990´s we have gained ever more understanding of cities as complex systems (e.g. Batty & Longley 1998, Portugali 2011, Allen 2012). Complexity is not an anomaly in the urban order, but rather it is the underlying rule of urban metabolism and spontaneous development. It is prerequisite for continuous urban evolution, which is the result of the emergence of self-organisation rather than a product of purely intentional design endeavours (Marshall 2009). To open up the discussion and identify crucial shortcomings of legal planning apparatus some key features of present day urban planning require critical examination.

First, there is the issue of the abstraction and entitation of space. The tradition of spatial planning and urban geography is firmly grounded on an object-ontology of hierarchically ordered spatial entities as well as on the notion of absolute space and measures of Euclidian geometry. An ontological and epistemological turn has involved a change of view from absolute space to space as relative and relational and recursive cross-scale. (Joutsiniemi 2010) Neither ecological nor socio-spatial phenomena yielding beyond territories in the present extremely networked urban geography can be restricted to governmental or other artificially constructed delineations.

Second, there is the notion of mono-functionality and hierarchical order opposing self-organisation. In urban planning the principles of universality, controllability and predictability prevail, echoing traditional modernist values (e.g. Morin 2007). Rational ideals that reduce complex planning tasks to mere efficiency maximisation efforts in order to maintain the functionality of the urban system have dominated planning for decades. By applying partial task optimisation strategies cities have been planned as dynamic yet simple systems consisting of mono-functional sub-systems and land use patterns. In this context the quality of the urban system equals its technical functionality. The ideal has been to create a failure-proof robust system (Snowden 2011), aimed at controllability and predictability, which would help minimise risks and increase resistance to sudden disruptions. According to the theories of resilience, mono-functional and homogenous urban patterns are more vulnerable to shocks, since they lack the critical properties that help cities to tackle and absorb disturbance through self-organisation. The interlocking and overlapping of spaces enables urban agents interact in various ways, adapting to each other's behaviour.

In fact, according to recent findings in urban geography the organisational principle of urban fabric is not-based on patches on a characteristic scale, but on multiple economic, social and political phenomena that reach across the scales. Fractal spatial division (Batty & Longley 1994) and distinctive interactions across multiple scales in present-day urban formations (Sieverts 2003) are clear indicators of the change. Alternative systemic definitions are needed and those based on flows and fluxes have quickly replaced those with aggregated spatial objects. The very same idea yet in more generic terms emerges from the literature of spatial resilience: "*Spatial resilience connotes issues such as spatial variation, fragmentation, integration, connectivity and scale of a certain time-space continuum.*" (Kärrholm *et al.* 2012 referring to Cumming 2011) Therefore the success of parcel-based land use regulation is not connected to the most suitable norm or definition of each parcel, but quite contrary, to the flexibility and tolerance of the norm to host alternate unpredictable activity.

Achieving flexibility and reflexivity through robustness and redundancies

First of all, the impacts of climate change cannot be predicted but we should increase preparedness and transition capacity by transforming urban environments to be more flexible or robust to face change. In the context of resilient thinking, robustness is a crucial property of system, since it helps maintain the system's functionality despite failures and allows alternative uses. In the literature, robust and resilient systems are kept distinct (see e.g. Snowden 2011, Pavard *et al.* 2007). Flexibility, or spatial resilience, would entail different usages, adaptations, affordances and changes without changing identity (Kärrholm *et al.* 2012). At the level of urban planning and design it implies cross-scale spatial strategies, multifunctional areas and flexible regulations and, operationalised at the level of the built environment, mixed-use, shared space, easily transformable and multi-modal concepts. The relaxation of functional separation is a tactic to explore the spatial potential from within and actively promote the diversity of urban activities to create new characteristics and flexibility for unpredictable future. Often border zones, whether those of regions, municipalities, districts, or boundaries created by land ownership or landscape, have the highest level of potential for multiple usage, but are poorly activated due to the practical single scale centre-periphery setting. (Alppi *et al.* 2007) These areas constitute a heterotopic potential, rich in redundancies that are needed for the urban system to be able to reorganise, nonetheless in unexpected ways. Another example of redundancies is what is known as 'urban fallows' (Oswald & Baccini 2003).

At the strategic level it implies adopting spatial strategies that are not strictly tied to specific resources or technologies, which means that the goals can be realised not *because* of them but rather *in spite* of them. Thus strategies may fail but their goals may be achieved. It follows that the outcomes of planning cannot be controlled by a comprehensive plan, but instead a preferred goal can be reached by taking incremental steps by experimenting and learning. For all stakeholders, adaptive capacity would entail clarifying goals not as the optimal solutions but as robust enough to be achieved in varying conditions.

Bridging strategies and tactics with new topologies

In our observation the current planning tools seem extremely partial. The main reason for this is that tools are mainly targeted to improve the zoning-oriented planning procedure rather than dynamic urban processes. A large portion of the planning knowledge, whether gained through participatory process or expert assessment, is in fact difficult to code to a language used in a legal planning instrument. Novel planning also needs a novel system-based vocabulary. Professors Franz Oswald and Peter Baccini have since the late 1990s introduced a holistic planning method called *Netzstadt*. This outlines a multivariable socio-ecological criterion and analysis framework suggesting that sustainability is implicitly embedded in cross-scale and reflective processes between urban morphology and metabolia (flows, interactions, transformation). The integrating approach chosen has in fact a deep family-resemblance with so-called lean production, where the background philosophy sees the fluxes and resources as opposite sides of a coin. The difficulty is to change the discussion from means to goals. In a dynamic urban landscape planning solutions are not good or bad, but the quality lies deeper in their characteristics. In their *opus magnum* Oswald & Baccini have outlined five criteria for the evaluation of urban quality: identity, diversity, flexibility, resource efficiency and self-sufficiency (2003).

In order to tackle the obvious mismatch between the scale-dependent normative planning world and cross-scalar development, the coding of urban environment should be reviewed. One possibility for this is to outline specific planning and design tactics that address the strictly configurational and physical properties that we recall generative urban typologies. The aim in this is to get a grip on the essential fluxes with the new norms that do not yet have fixed solutions. As an example we point to Alppi et al. (2007) who suggest novel normative planning typologies for spatial regulation and guidance. These are: Urban extension, Edge framing, Urban infill, Urban strip, Buffer activation, Multimodal node, Fallow mix and Connecting node. In brief these can be understood as follows:

Buffer activation: The specialized production and maintenance of urban infrastructure has a tendency to allocate superfluous spatial buffers to ensure their imagined future needs. Infrastructural buffer intensification is a call for diverse actors of urban field to negotiate acceptable solution and backup plans. Typically this happens in traffic arteries, but is in fact more related to single-minded land holding issues and also found, for example, in waterworks and so-called ecological corridors. Multimodal node, Fallow mix: The zoning laws have created an illusion of an absolute space where aerial labels and land parcels have one to one correspondence. The relaxation of functional separation is a tactic to explore the spatial potential from within and actively promote diversity of urban activities to create new characteristics and flexibility for an unpredictable future. Edge framing, Fallow mix: Edge articulation is a primary tactic to reach beyond administrative boundaries that have created spatial practices of their own. Often border zones, whether those of regions, municipalities, districts, land ownership or landscape, have the highest level of potential for multiple usage, but are poorly activated due to a practical single scale centre-periphery setting. Spatial code reversal: This is a tactic resulting from observing each location from multiple perspectives. Diverse viewpoints allow planners to find the most usable level of connectivity and focus on the potentially most fruitful neighbourhood size for development. Instances of spatial code reversal can be seen, for example, in the creation of new lot-street interface, edge framing or in emergent node and edge city formations.

The very same principles highlighted here appear in a study by Wardekker et al. (2009), where the writers outline strategies and tactics to enhance resilience in environments most likely to be affected by climate change. These options for increasing resilience found in Dutch delta areas have been named Homeostasis, Omnivory, High flux, Flatness, Buffering, and Redundancy (see the original text for more details).

Conclusion and discussion

We have observed the adaptive capacity of urban systems and planning by reflecting their resilient potential. From planning ideology we have identified a common, but unfortunately overly optimistic hypothesis to brace oneself for future. We have argued that this is due to the underlying assumptions of normative planning ideals – of the predictability and prevention of negative effects, instead of admitting to the uncertainty, the inevitability of disturbances and recognising the self-fulfilling nature of prophecies (Portugali 2011).

To steer away from this, an alternative perspective is needed. As Batty states (2013c, 5): "In the 21st century, disruption is going to become the new normal in ways that we can't even predict. All we can do is learn to bounce back better...In fact we now have quite a lot of science to help us in thinking this way and much of this grows out of the systems approach, its successor complexity theory, and of course its specific tools such as network science." Therefore in strategies of spatial planning, attention should be paid to the special implications of resilience at different scale levels and cross-scale interactions. The question concerns the spatial scales as well as the time scales of forecasting, as the shift to big data is turning the focus of planning from small to a bigger scale, and from long term to short term prediction (Batty 2013c). The emphasis should be on the creation and support of spatial and functional diversity and redundancies as a critical property for enabling reorganisation of the systemic parts to adapt to changing conditions. Inevitable transformation is implicit in complex evolutionary processes: we only need to change the emphasis of resilience from maintaining unsustainable systems to rethinking and redefining alternative functionality.

The proponents of self-organisation and a growing body of "urban scientific" research have raised antagonism to planning by arguing that cities are like natural organisms taking their own course in spite of planning, and indeed, planning can have adverse impacts on spontaneously evolving human-environmental processes. According to this view, planning should concentrate on monitoring the evolution and steering the process with focused and incremental interventions so as to help agents to self-organise towards a preferred goal. It is therefore important to note that identifying ongoing spontaneous and transitional trajectories within the urban system does not exclude the need for a general discussion on future directions. On the contrary, it calls for outlining values, setting goals and constant reflection on the progress towards the declared objectives.

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Transport Climate Policy Choices in the Helsinki Metropolitan Area 2025 – Views of Transport Officials and Politicians

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Transport policy is increasingly concerned with the reduction of CO_2 emissions. However, the use of passenger cars has not been reduced in the Helsinki Metropolitan Area, and more effective measures are needed. There are numerous different types of policy tools available, and many are needed simultaneously, forming policy packages. In this research, the views of policy-makers (transport planners in city administration as well as elected city council members) in the Helsinki Area are studied. The views were collected using interviews and a questionnaire, where the respondents estimated the effectiveness and acceptability of various instruments, as well as which instruments would be in use in the Helsinki Area in 2025 in probable and preferable futures. The results include four policy packages that have been composed of the future images envisioned by the policy-makers. In addition, barriers to the uptake of effective policies are identified and discussed. Examples of such barriers are the differing objectives of various actors, lack of communication and trust, and uncertainty about the effectiveness and societal acceptability of policy tools.

Introduction

Transport policy is increasingly concerned with the reduction of CO_2 emissions. Transport causes a fifth of the CO_2 emissions from Finland (Jääskeläinen 2010), and urban transport a fourth of transport emissions within the EU (CEC 2011). Various transport policy tools, e.g. information guidance, economic measures, and restricting norms, are used to affect transport needs and volumes, choice of vehicle (i.e. modal split), and technological development. Individual policies form a policy mix, and they can support or hinder the effectiveness of each other (e.g. May and Roberts 1995). While some transport policies are national, such as taxation, many are decided and operate on the local level. A previous study about Finnish transport sector's future discovered that many experts are pessimistic about whether sufficiently effective emission-reducing transport policy measures can be taken to use in Finland (Varho 2012).

Urban policies include 'carrots' for sustainable transport choices, such as providing information, public transport, and infrastructure. Improved land-use planning and the co-planning of transport and land-use have also been important administrative tools, but land-use has been excluded from this study. Parking place policy (costs and restrictions) is among the coercive urban transport policies in use.

Finland is a sparsely populated country, with sprawling, smallish cities. Four of these (Helsinki, Espoo, Vantaa and Kauniainen) are located next to each other in the Helsinki Metropolitan Area. Helsinki has 600,000 inhabitants, Espoo 260,000 and Vantaa 205,000. Kauniainen, the fourth 'city' has fewer than 9,000 inhabitants, but it is entirely surrounded by Espoo and is considered part of the Helsinki Metropolitan area. The wider Helsinki region has some 1.3 million people now and the figure is expected to grow by another half a million inhabitants by 2050, increasing pressures on the transport system and transport policies (HSL 2011).

City transport policy is created in co-operation of two distinct groups: the transport planning administration and politicians. In Finland, the city council has the highest authority on city matters, and is elected in popular elections for four-year-terms. Usually the city council appoints members to a committee that focuses on urban planning and transport. Some of the council's authority is delegated to the committee, so the committee members have a large role in adopting new transport policies. Very significant issues, such as expensive infrastructure projects, are decided by the entire council.

In this research, the views of 15 policy-makers (transport planners in city administration as well as elected city council members) in the four cities of the Helsinki Metropolitan Area were studied. Using a questionnaire that was mailed to them, the respondents estimated the effectiveness and acceptability of various instruments, as well as which instruments would be in use in the Helsinki Area in 2025 in probable and preferable futures. The respondents were then interviewed and the interviews were analysed using qualitative content analysis in order to discover barriers to effective transport policy in the region. Alternative policy packages were constructed from the questionnaire responses.

Material and methods

Views from members of the relevant committees (who were also elected representatives in the city councils) and representatives of the transport administration were collected. The respondents came from the four cities of the Helsinki Metropolitan Area. One interviewee was from a regional transport organisation. The respondents are characterised in Table 1. They were selected in order to find variety of views and to cover the field. A problem that was encountered was that many city council members were extremely busy and declined to even answer e-mails sent to them where they were invited to participate. Therefore there were fewer politicians and they represent fewer parties than was planned. As considerable variation of views was found, however, and as the research is qualitative and to some extent explorative, it is estimated that this group fulfilled its purpose.

Table 1. The respondents.

City					Background organisation			Party (council members)		
Helsinki	Espoo	Vantaa	Kauniainen	not city level	city government	city council	other	The National Coalition Party	The Greens of Finland	The Finns
5	4	3	2	1	9	5	1	2	2	1

Gender		Age				Field of education		Level of education		
female	male	30–39	40–49	50–59	60+	technical	other	master's degree	bachelor's degree	other
7	8	2	2	6	5	11	4	11	2	2

The views of the respondents were collected in the spring and summer of 2013 using a questionnaire and interviews. The questionnaire contained 58 policy tools that had been grouped into nine sets: driving charges, driving restrictions, parking, planning, public transportation, city's own activities, information guidance, infrastructure, and large infrastructure projects. The grouping was influenced by e.g. the policy typology by Sairinen (2000, p. 38). Policies were selected based on transport sector publications and preliminary interviews with three representatives of the Helsinki transport administration.

The same questions were asked regarding each policy instrument: effectiveness in cutting CO_2 emissions, societal acceptability, use in 2025 in probable future, and use in 2025 in preferred future (the best future the respondent could realistically envision). Each was asked using a seven-step Likert scale. For large infrastructure projects the scale was 1-3 (not built, being built, in use). The questionnaire is demonstrated in the Appendix.

The respondents sent the filled-in questionnaire back a few days before a semi-structured thematic interview was conducted. During the interview, missing questionnaire responses were filled in and previous answers could be changed if desired, but the main focus was on qualitative questions. They were prepared in advance, but all questions were not asked from each interviewee, and their order varied. The interviewees were asked about the decision-making process, the roles of administration, city council members and the public, about their arguments concerning some policy tools, why their probable and preferred future policy mixes differed from one another, etc. The interviews were audio-taped and transcribed. Interviews were analysed using directed content analysis, in which excerpts from the text were coded using partly predetermined codes that were based on previous research, but new codes were also added to the coding scheme when new interesting topics which could not be included in the existing codes emerged from the material (see Hsieh and Shannon 2005). Direct quotes in this paper have been translated from Finnish by the author.

The views expressed in the questionnaire were grouped using agglomerative hierarchical clustering, (e.g. Everitt et al 2001). Cluster analysis is a statistical tool that grouped the 28 images of the future emerging from the questionnaires into a manageable number of 'clusters' of answers that are mathematically close to one another. The idea was to find policy mixes that would represent different approaches to transport policy.

The final number of clusters could not be determined in advance. Instead, the clusters were experimented with and a number that would be both informative and relevant was searched for. Four clusters were selected, because logical differences could be observed between them. These clusters revealed four different viewpoints towards the policy instruments.

For each policy tool (separately for each cluster), the average of the values given in the future images that ended up in that cluster was calculated. For example, the first cluster consisted of 4 images of the future, which had the values 2, 1, 3, and 1 for the variable "Road tolls on entry roads to Helsinki". The average (1.75) was the first cluster's value for the said instrument. Then those policy tools that received the average value ≥ 4 were picked. The included instruments were considered a policy package: different sets of tools that are used to a different extent. The policy packages are discussed in the next section and illustrated in Figures 1 and 2. The figures are meant to illustrate the general differences and similarities between the policy packages, and for that reason are placed next to one another. The focus should be on the number and length of bars in the figures, rather than the specific policies.

Four policy packages

The first package *Infrastructure!* (Fig.1) represents a viewpoint that transport policy consists mainly of infrastructure projects. Both large-scale rail and road projects are included as well as additions to bike paths and pedestrian zones. The future images included in this package did not include much other regulation, in particular no restrictions or fee raises. Since infrastructure is expensive, this is not a *laissez-faire* set. It focuses on methods to expedite transport.

Regulation, regulation! (Fig.1) is a package that includes much regulation across the sector. Both infrastructure and lighter methods are invested in heavily. Of the 58 policy tools presented in the questionnaire, only four were left out of this package. In contrast, *Infrastructure!* package lacks 42 of the 58. Although three expensive infrastructure projects were excluded from the *Regulation, regulation!* package, it is still a set that would require a great deal of resources.

Information and technology (Fig.2) is the third policy package. Various information systems and the advances of technology are emphasised within this package. Included are more traditional tools such as *cycling campaigns* and *information about routes and fares of public transport*. In addition, there are more modern ICT methods such as *road use charges based e.g. on satellite navigation of individual cars*. Even more futuristic methods such as *automation of public transport* are included, as well as tools that can affect the choice of new cars, such as *developing biogas or hydrogen charging network to the Metropolitan area*. There are also many other policy instruments, such as rail infrastructure projects.

The last package is called *Better governance*. There is the same "amount" of regulation in the last two packages (Fig.2), and the difference between them comes from the emphasis between various policy tools. *Better governance* includes numerous policies that aim to improve city government. For example, there is *promoting electronic communication in city services*, and *co-operation of city government sectors in order to minimise transport*. Some infrastructure projects are included, but their importance is smaller than in the other packages.

In all, the differences between the four packages are fluid and interpretation of the sets has been sought for, for example, from the strenuousness of support – even if the same tool is in several packages, it may have been used more in one of them.

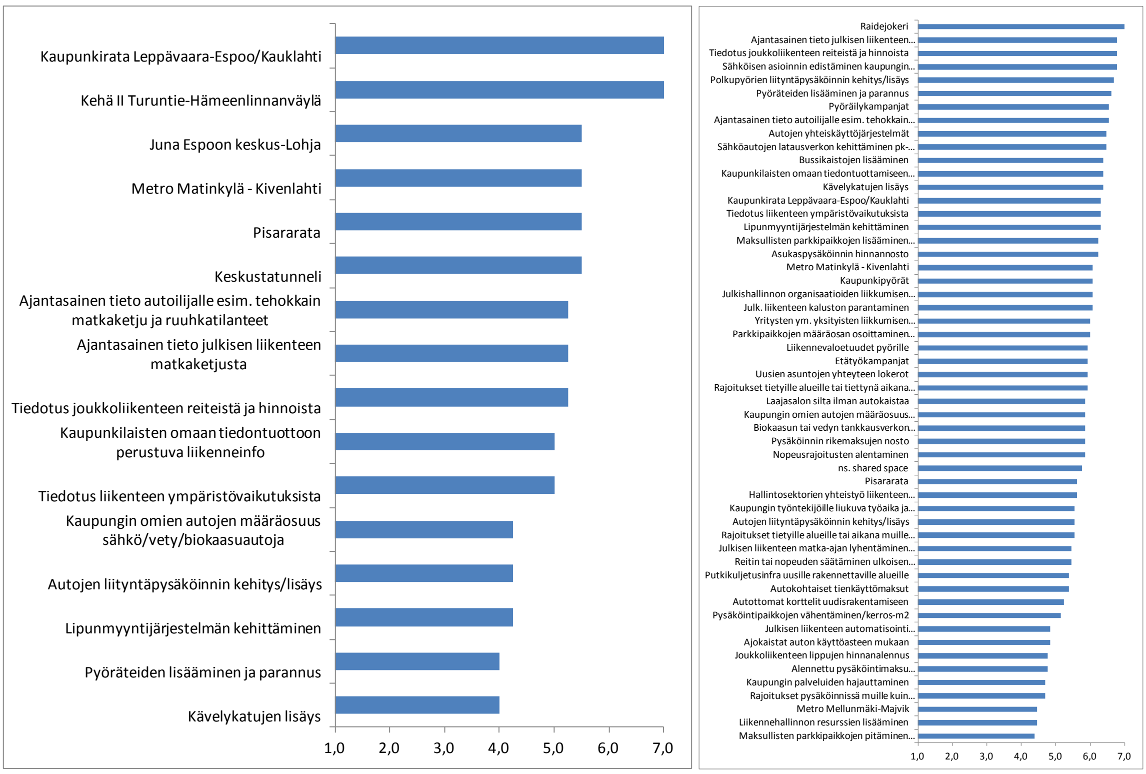

Figure 1. The policy structures in 2025 of the **Infrastructure!** package (left) and of the **Regulation, regulation!** package (right). Only policy tools that received the average value ≥ 4 are included. (1=not used at all, 7=used very strenuously.)

Most respondents had more regulation in their preferred than probable future image. This means that they hoped for more stringent regulation, but believed there to be some obstacles in the real life to their introduction. However, the trend was not the same for each policy tool. Instead, a respondent could in general hope for more stringent policy than he/she considered probable, but to simultaneously have fewer bus lanes in the preferred image than in the one he/she considered to be probable. This illustrates the fact that the whole formed by individual policy tools is very complex. Each instrument needs to be considered individually, and yet it is necessary to take into account their effect on one another and their joint impact. None of the policy packages presented here is based on a single respondent, and therefore does not necessarily exactly reflect the view an individual has had.

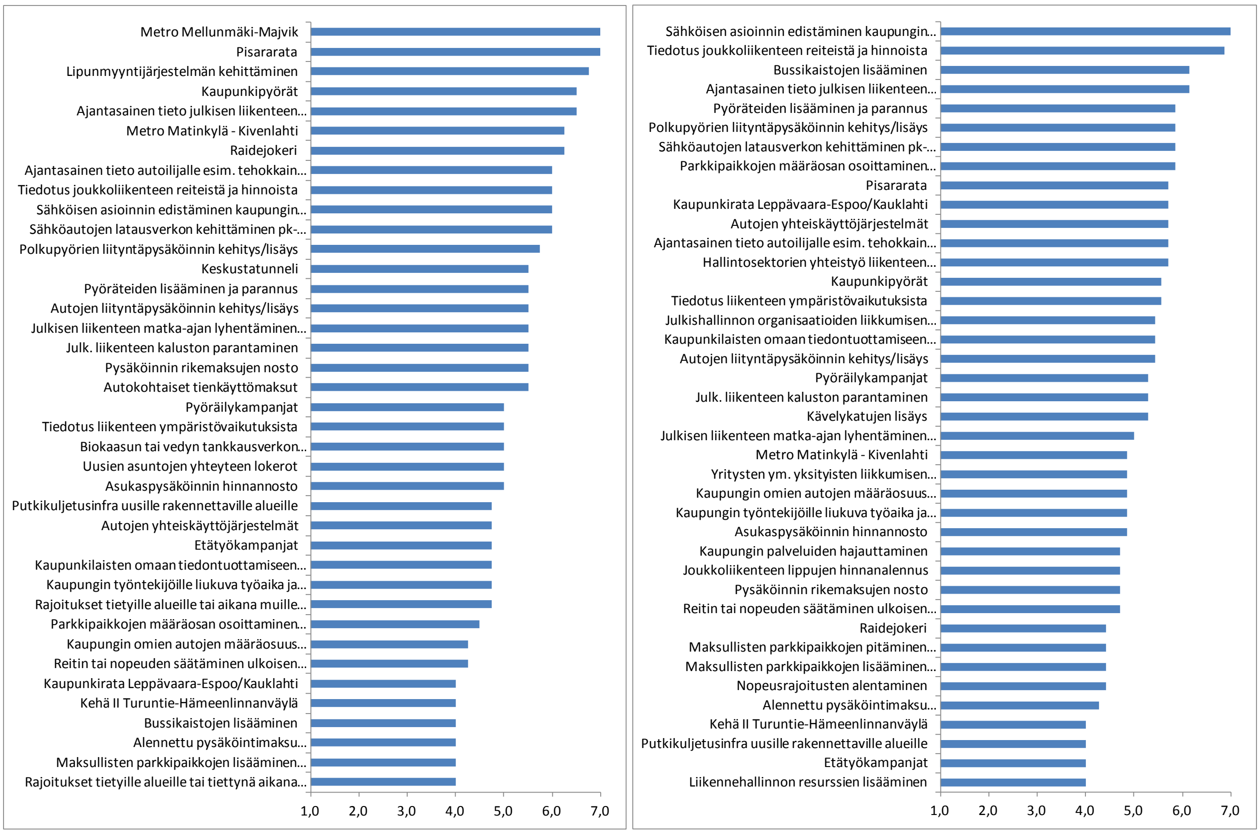

Figure 2. The policy structures in 2025 of the **Information and technology** package (left) and of the **Better governance** package (right). Only policy tools that received the average value ≥ 4 are included. (1=not used at all, 7=used very strenuously.)

Each package included answers of representatives of at least two cities, and of both transport officials and city council members. The answers of representatives of any given city did not end up in a single package. The differences between the policy packages seem to reflect deeper differences in views about the direction of transport policy rather than the differences between cities or between administration and politicians. It is possible that with a larger sample, a statistical difference could be detected between such groups, but these results indicate that there is considerable deviation within each group.

Barriers

The analysis of the interviews revealed factors that affect policy choices. The interviewees discussed their reasons for favouring or not favouring certain policy instruments, but they also described the policymaking processes in their cities. The following discussion is by no means exhaustive. Instead, a few interesting topics that seem to cause obstacles to effective transport policy in the Helsinki Metropolitan Area have been raised.

Objectives

Although all respondents considered climate change to be an important topic, they placed differing weight to it. This means that not all consider the CO_2 emissions particularly in their estimates about desirable climate policy. Not having emission reductions as an important objective is clearly a barrier for effective climate policy. Several noted, however, that the means for reducing greenhouse gas emissions often correspond with other transport policy objectives. Supporting public transportation, cycling and walking improves the flow of traffic, saves space and resources, and reduces also other emissions than CO_2.

> *Traffic is reduced, which means then less traffic on streets, less emissions, less noise, better environment for the inhabitants.*

On the other hand, even if emissions reductions are a priority, the preferred means to reach them differ. Emissions can be reduced by influencing the need and volume of traffic, by influencing the modal split (i.e. choice of vehicle or transport mode), and by influencing the technology in use. All of these were considered the preferred method by some interviewee, the "votes" being 5 for transport volume, 6 for modal split, and 3 for technology. The role of technology, in particular, divided the respondents' views. A few believed that new technology would solve the problem within a few decades, others strongly disagreed.

Particularly when choices are made between various policy tools, also other, perhaps less tangible objectives emerge. For example, freedom of choice was emphasised by some interviewees.

A: I consider freedom an important issue and we should dare to use the good aspects of this country for the betterment of the citizens, and believe in our ability to technologically manage these problems, rather than through this regulation and transport policy.

Q: It seemed to me there [in the questionnaire] that you favour more carrots and…?

A: Yes, carrots more than sticks […] Like public transportation, of course […] I believe that it should be used and much is done for it, but I would like it to be everyone's personal choice. […] I want that people choose by themselves and are entitled to it. I want to live in a free country [laughs].

Differences in objectives cause differing views about the best policy instruments. This is not exactly a barrier to effective policy, as there is no certainty about what actually constitutes the most effective policy, but it is likely to lead to less determined and unified policy.

Effectiveness of policies

The respondents' estimates about effectiveness of policy instruments varied a lot in the questionnaire. They also often noted that the effectiveness of policy instruments is not well known. In particular, several interviewees noted that the impact of policies on human behaviour is poorly understood. When the interviewees were asked to identify future research needs, several pointed this out. They would like to know more about the psychology that affects transport choices. Although the field of transport psychology exists, it has often focused on other topics, such as risk behaviour or observation of the driving environment. Environmental transport psychology seems to be a growing field, however, and consumer research may also help in understanding individuals' decisions regarding transport modes and volume.

> *How to affect people's lifestyle and choice of own transport mode, that's another [issue]. It is a little like soap that slips out of your hands, so that even though we would like to make joint transport policy, can we get any kind of grip of the city dwellers?*

Societal acceptability

The question regarding societal acceptability of policy tools turned out to be unclear in the questionnaire. It was asked simply as 'societal acceptability' by which was meant how city inhabitants and the political decision-makers view the instrument. However, several respondents understood it to mean whether the suggested policy tool is good for the society as a whole (fair, cost-effective, etc.), and a few respondents mixed the two approaches in their evaluation.

Nevertheless, 14 out of the 58 instruments were given values ranging from 1 to 6 or 2 to 7 by the panel. Another 11 instruments received values from the whole range of 1 to 7. This seems to indicate that the respondents have very different opinions about the societal acceptability of many policy tools, whichever point of view they are being discussed. Again, this means that unified policy is difficult to achieve.

Resources

Resource scarcity is a rather obvious barrier, recognised by all interviewees. There is never enough money to do all the things that could be useful. In transport, the most resources go to infrastructure, although there is a huge difference between building a highway intersection and building a bicycle path or an underpass. In addition, bus services, parking places, information and campaigns, the transport administration etc. all require funds. However, only a few interviewees considered the lack of funds for the administration (personnel) itself to be a barrier, usually they only discussed whether funding is available for the projects planned or executed by the administration.

Information is another form of resource that could potentially form a barrier. This did not emerge in the interviews, however. It was universally acknowledged that the administration has more knowledge about the transport issues and policy instruments than the council members, due to their education and work experience. This was not usually considered a problem, however. The transport planners have "informational power" but the formal decision-making power remains firmly with the politicians. This was considered appropriate. However, some issues relating to information seem to cause problems, namely lack of communication and trust across various sectors.

Lack of communication and trust

A central theme in the interviews was the co-operation between transport planners and council members. Interviewees were fairly content with the co-operation and mutual appreciation was often expressed. For example, the council members were described as hard-working, effective and willing to openly discuss issues. Transport authorities' expertise and knowledge were recognised. However, the communication between the two groups is not always easy. Some expressed detailed critique about the way matters are presented to the committee. More general comments expressed a need for better communication between the different parties.

> *The communication is, after all, kind of that some transport planner [...] works alone in some cubicle for a year and a half, perhaps based on some preliminary instructions given by the committee, and then he comes to the 15 minute information session to present it and there's about ten people there telling him that it just stinks.*

On the other hand, several transport planners explained that there is a lot of unofficial communication. The attitudes of the committee members towards some new ideas and initiatives are unofficially sounded in advance. Ideas that seem very unpopular are often never taken to the committee at all. This may be a sound use of planners' resources, but it hints at self-censorship that can also be a barrier to effective policy.

The roles of the two parties are so different that there is sometimes a lack of trust between the two. This was not expressed by all interviewees, but some emphasised it. The transport administration is sometimes seen as driving its own agenda where particularly some influential individuals may try to manipulate the process. Some even considered much of the administration and planning work unnecessary.

> *And then these smaller-scale measures [...] they are all about big brother watching and, we hire people to monitor and plan and build obstacles and regulations. When you now look at the state of the economy, we should remove all these silly things from the public side and put those people to real work, stop them from coming up with all this [regulation].*

Some transport planners, on the other hand, openly considered the politicians to be weak or otherwise unable to create effective policy.

> *We members of the administration, we don't know everything but we do have pretty good idea of how transport and land-use should be planned. And then politics and through them city inhabitants, they may think only about how it is nicer to move in a particular way and to do things in a particular way and so we don't get to do the things that are essential for cutting emissions. [...] Everybody knows it but it is just not said out loud.*

Another issue are the relations between the four cities of the Helsinki Metropolitan Area. There are many organisations where they are represented and there are also bi-city meetings as well as unofficial communication between transport planners of different cities. There is significant co-operation and communication. However, as the four cities all have their own histories, characteristics, and agendas, some conflicts are inevitable. Interestingly, politicians seem to have little contact across city borders, except for the official multi-city organisations. For example, members of a political party do not seem to communicate much with their party members across city lines. This is probably partly due to the lack of time, as the city council members are very busy: they not only have their regular jobs but the political appointments as well.

In any case, the lack of trust between cities, particularly that of smaller cities towards Helsinki is a potential barrier in effective transport policy.

Historic reasons

Several interviewees noted that the administration, the political system, and the transport infrastructure, culture and legislation have all developed over a considerable period of time. They were seen to be rather entrenched structures, infrastructure most of all. Therefore very rapid changes were not usually envisioned or considered possible. In addition, a great many transport policy tools are already in use or under consideration, as evidenced by the length of the questionnaire in this study!

Discussion and conclusions

There is no single research frame for policy choices. Policy choice has often been studied through the characteristics of the measures themselves, such as effectiveness and efficiency, and often through the policy-making process (Niles and Lubell 2012). This study belongs to the latter school of thought, embracing also the unique nature and context-dependency of each case (Paloniemi and Varho 2009) and emphasising, as Linder and Peters (1989) have done, the subjectivity of decision-makers in policy instrument selection.

All around Europe, cities have set their own climate targets in addition to the national and EU targets. There is a goal to reduce the per capita greenhouse gas emissions from the Helsinki Metropolitan Area by a third from 2004 levels by 2030 (YTV Helsinki Metropolitan Area Council 2007). In that sense, there is a clear objective to reduce the emissions also from the transport sector. However, the results show that actors weigh the various objectives of policy individually, and do not necessarily approve of some tools that could cut down emissions effectively.

Different cities have different objectives and decision-making processes, which means that the results of this study are not necessarily applicable in any other city. Of particular interest, however, was the finding revealed by the clustering of views that preferences were not determined by either city or the role (administration vs. politician) of the policy-maker.

Sometimes policy choice has been thought to reflect the actors' own interests or estimates about voters' views (public acceptability). Perhaps surprisingly, party politics were not very evident in the material, although interviewees observed some general differences between political parties. Results regarding public acceptability were not conclusive, but indicated that the policy-makers' estimations about the city inhabitants' willingness to accept individual policy tools vary greatly.

Some transport policy research shows that the decision-makers' views do not necessarily reflect research results on the impacts of policy measures (Meek et al. 2010). This phenomenon was observed in this study as well, although more in the sense that the respondents considered the effectiveness of policy instruments to often be poorly known, particularly in terms of impact to city dwellers' behaviour. Their own estimates about effectiveness also varied greatly. The experienced lack of information about the effectiveness of policy instruments is clearly a barrier to effective policy, but at least a potentially solvable one.

Somewhat worrisome are the strained relations between different policy-makers. These might improve with better communication, but with the lack of time available, communication is not always easy to arrange. The many barriers discussed here clearly reflect *bounded rationality* that has been recognised in some policy choice models, i.e. the limited information, time etc. that is available to decision-makers (Böcher 2012).

In addition, historic reasons and policy structures were found to inhibit transport policy change in the Helsinki Metropolitan Area. Path dependency, institutional slowness and the huge number of alternatives have also been identified in previous studies as factors that hinder the use of new types of transport measures (May et al. 2012).

Very rapid changes can hardly be expected in either transport policy or transport habits in the Helsinki Metropolitan Area. Nevertheless, the results show that there is a lot of discussion, active politicians, capable administration, and numerous policy options and innovations that affect the sector and its emissions. Some change seems inevitable.

More information about this study is available in Finnish by Varho (2014).

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Appendix. Sample of the questionnaire (translated from Finnish).

City's own activities	EFFECTIVENESS IN CUTTING EMISSIONS							SOCIETAL ACCEPTABILITY							PROBABLE FUTURE 2025							PREFERABLE FUTURE 2025						
	1= not at all effective						7=very effective	1=not at all acceptable						7= fully acceptable	1=not in use at all						7=in very strong use	1= not in use at all						7= in very strong use
Flextime and teleworking opportunities for city workers	1	2	3	4	5	6	7	1	2	3	4	5	6	7	1	2	3	4	5	6	7	1	2	3	4	5	6	7
Decentralisation of city services in order to diminish traffic (e.g. health centres, day care centres)	1	2	3	4	5	6	7	1	2	3	4	5	6	7	1	2	3	4	5	6	7	1	2	3	4	5	6	7
Co-operation of administrative sectors to minimise transport (e.g. calculating the travel of children to a new school to the costs of closing a school)	1	2	3	4	5	6	7	1	2	3	4	5	6	7	1	2	3	4	5	6	7	1	2	3	4	5	6	7
Increasing transport administration resources	1	2	3	4	5	6	7	1	2	3	4	5	6	7	1	2	3	4	5	6	7	1	2	3	4	5	6	7

Parking	EFFECTIVENESS IN CUTTING EMISSIONS							SOCIETAL ACCEPTABILITY							PROBABLE FUTURE 2025							PREFERABLE FUTURE 2025						
	1= not at all effective						7=very effective	1=not at all acceptable						7= fully acceptable	1=not in use at all						7=in very strong use	1= not in use at all						7= in very strong use
Raising parking ticket price	1	2	3	4	5	6	7	1	2	3	4	5	6	7	1	2	3	4	5	6	7	1	2	3	4	5	6	7
Lower parking fees to electric/hydrogen/biogas vehicles	1	2	3	4	5	6	7	1	2	3	4	5	6	7	1	2	3	4	5	6	7	1	2	3	4	5	6	7
Limitations in parking to non-electric/hydrogen/biogas vehicles	1	2	3	4	5	6	7	1	2	3	4	5	6	7	1	2	3	4	5	6	7	1	2	3	4	5	6	7

Population and Consumption Futures in the Urban Transition: Case of India

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Population growth and per capita consumption underlie all other present drivers for global environmental change. Our planet's population may rise to more than 9 billion by the middle of the century with India being one of the most populous countries. This will put immense strain on natural resources such as fresh water, oceans, land and soil, raw materials and non-renewable energy resources, as well as biodiversity and ecosystems at large. This study investigates the joint impact of population and consumption change on the environment, unveiling the effect of urbanisation. We contrast demographic change and consumption in cities and rural areas for India by making use of the population life table, and apply vegetable/meat consumption and CO_2 emissions indicators. The impact trajectories represent the compound effect of population x consumption on the environment. Through the trajectories we can demonstrate possible consequences of different fertility and consumption scenarios across an urban-rural divide. Early results reveal the benefits related to the urbanisation trend. More widespread information about the environmental implications of individual consumption is thought to bear the potential for reducing the future strain on natural resources.

Introduction and Background

Consumption patterns drive natural resource use and production largely on the global scale, but not exclusively. In some countries, such as India, many products are consumed within the country, and hence local consumption drives local production. While our planet's population is slowly rising to unprecedented levels (United Nations 2013), the current consumption patterns are unsustainable from an environmental point of view. This has been highlighted by many researchers, most notably Rockström and co-workers (2009). It is becoming clear that the current resource-intensive economic growth model can't be extended across the globe. Nations must adapt their production and consumption habits to respect the limits of the environment.

Increased information about the interplay between scarce natural resources, population dynamics, and the effects of individual consumption are needed (Mace 2013). Deeper understanding of the complexities of the human-environment nexus may promote cross-cutting work, stakeholder interaction, individual choices and ultimately policy action around natural resource demand as well as production through that demand. This will benefit the environment at large, and desirably also promote more sustainable economic activity.

A measure of human environmental impact can be given through the compound effect of per capita consumption and population structure. The consumption of natural resources, renewable or otherwise, is shifting as the world is turning more urban and wealthy. Urbanisation translates into intra-country population dynamics and is often related to increased economic activity and wealth. Urban living is thought to increase consumption as a whole, while proximity of people and places may produce economies of scale in some sectors such as transport and housing. Changes in fertility play a role in shaping population (and household) structure for many decades to come, while age, household size and urbanisation have been shown to correlate with different consumption levels (O'Neill et al. 2012). Added complexity arises through cultural consideration of consumption habits.

(Fuel) poverty is an additional issue of concern especially in rural developing regions. Modern energy sources are not needed only for quality of life and economic activities enabling growth, but also play an important role in environmental and public health considerations. Rural communities in e.g. India are still reliant on traditional biomass for their everyday energy needs such as cooking, which has adverse effects on the whole community including people and the environment (Ekholm et al. 2010).

This paper focuses on India for several reasons. It is the second largest country in the world in terms of population, with urbanisation on the rise. It is expected that by 2050, more than half of India's population will be living in urban areas. Given the challenges of rural areas to meet inhabitant's resource needs (natural and economic), and the expectations around urban prosperity, the trend of moving to cities is not surprising. At the same time, India is one of the most populous countries that has been very agrarian in terms of settlement patterns right up to current times, and therefore has an unprecedented potential for urbanisation. Based on the 2011 census, just over 31% of Indians live in cities, compared to just under 28% in 2001. Coupled to lowering fertility rates in the urban domain, this trend may be beneficial for both the country and its population as a whole. What then are the implications of Indian urbanisation for the environment?

This study investigates the joint environmental impact of population and consumption change at sub-national level in India. Earlier work concentrated on country level comparisons for India and the USA (Mace et al. 2013). Our project unveils the net effect of urbanisation and consumption using comparable national statistics as well as microdata. We contrast demographic change in cities vs. rural areas by making use of the population life table, and apply vegetable/meat consumption and CO_2 emissions indicators. The indicators were chosen based on commonly accepted environmental impacts: CO_2 emissions on climate, and food consumption on land use. The obtained environmental impact trajectories represent a net effect of *population* x *consumption* on the environment. Through the impact trajectories we can demonstrate possible consequences of different fertility and consumption scenarios across an urban-rural divide. The trajectories may be used to inform policy options with respect to consumption or emissions as well as meeting the need for family planning.

The paper is structured as follows: The next section describes the model and data used under 'Material and Methods', followed by results with brief descriptions and figures. Discussion and conclusions are combined in the last section that also incorporates plans for further work.

Material and Methods

The projections carried out follow the well-known cohort-component method. In this method, the number of people surviving to the following time frame $t+1$ are estimated using the mortality and fertility at time t. Jump-off population for the simulation starting year 2011 (baseline data) were obtained from the most recent census (Government of India 2011). A column vector $n(t)$ describes the population structure at time t. Age-specific survival data $p(x)$ was given by $l(x+1) / l(x)$ where $l(x)$ is the number of people at age x. We then use the age-specific survival and fertility rates to construct a Leslie matrix, A. Next we create a column vector $e(t)$ of the same length as $n(t)$ consisting initially of 1s, to be substituted by the different consumption multipliers (rural / urban). We then define a vector describing age-specific impact, $g(t) = n(t) \circ e(t)$. Our population model is $n(t+1) = An(t)$ and at each time step (0 to 50 years from now) we calculate $g(t)$. In order to explore various scenarios we define trends e.g. such that either the fertility, $m(x)$ decreases by a set proportional amount each time step, e.g. $m(x, t+1) = m(x, t) * 0.99$ and/or consumption $e(t)$ changes. We also use scenarios based on external data for consumption, as in the case for emissions (see Results). We calculate total population size at time t as $N(t) = \sum n(t)$ and total impact as $G(t) = \sum g(t)$.

Data sources in addition to the Indian census data include microstudies (Pachauri 2004; Ray 2007) and NSSO data (NSSO 2013) released by the Indian Government. The microdata were used to gain a rough estimate of the urban and rural consumption differentials. An extract from the International Institute for Applied Systems Analysis Greenhouse Gas Initiative (GGI) database (IIASA 2013) was used to calculate a region-specific per capita emissions outlook which was then applied to India.

The model is normalised to equal one (=1) for number of people for the urban and rural models at the start of the simulation, i.e. the current difference in urban vs. rural population is not taken into account in order to emphasise the per capita impact on the environment. The differential in the development of the numbers due to migration from rural to urban locations could theoretically be taken into account just like the differentials in fertility and mortality are. Migration, however, is not currently implemented in the model due to lack of reliable data, i.e. time series data on urban and rural population change that would differentiate between natural population growth or decline and migration. Also, the scenarios depicted here are not based on historical trends but merely emphasise the current difference in rural and urban population structure. Dynamics in the trajectories comes through the differentials in demographic variables, and in certain scenarios through implemented transitioning (to higher CO_2 output levels or convergence of rural to urban scenario for both consumption and fertility). Production-based consumption (or emissions) is not explicitly taken into account in the current model.

Results

The model results, using the most recent Indian population data, show a perhaps surprisingly low population development for the coming decades (see Figure 1.). The y-axis shows the 'Proportional impact on the environment' where per capita impact is set equal to 1, and population is normalised at 1 at $t=0$, and later values are compared to that, while the x-axis depicts years from now.

For India as a whole, total fertility rate has gone down considerably between the two most recent censuses (2001 and 2011), from 3.1 to 2.4, while the urban fertility is already below replacement levels at 1.9 (Government of India 2011), where replacement fertility is often quoted as an average of 2.1 children per woman. With a relatively high mortality rate, the overall population development then becomes one where the urban populations experience natural decline inside the coming 50 years or so. This is assuming zero migration (unlikely) and continuation of current fertility and mortality trends.

Essentially, given the present population development, Indian rural populations would have a greater environmental footprint that the urban ones, if everyone consumed 'the same' = 1 throughout the projection period (unlikely). By 2050 (under 40 years from now) the rural footprint would be about 1.5 times that of the urban, or indeed the current level due to natural population increase only.

Figure 2 shows the compound effect of population x consumption, where CO_2 emissions are used as proxy for energy consumption. The starting point difference between rural and urban trajectories manifests to the existing difference in energy source: rural populations depend more on high-emitting energy sources such as biomass, increasing their per capita emissions beyond their urban counterparts (cf. microdata sources under Material and Methods).

The purple dashed and solid lines (two topmost ones from year 20 onwards) correspond to urban and rural projections (as opposed to the 'static' black curves) with upwards shifts in emissions in the decades to come. The difference in the end points of the projected vs static curves testifies to the propagation of the impact of a greater population: when more people consume even slightly more, the end result is a non-linear increase in impact on the environment. Both urban and rural projected emissions are based on the same per capita emission database, and the urban-rural differential multiplier (obtained from microdata) is kept constant with time.

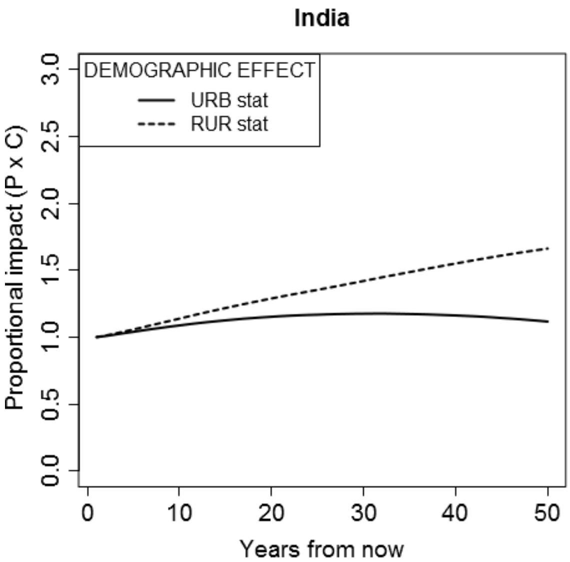

Figure 1. Urban and rural population trends: consumption unchanged.

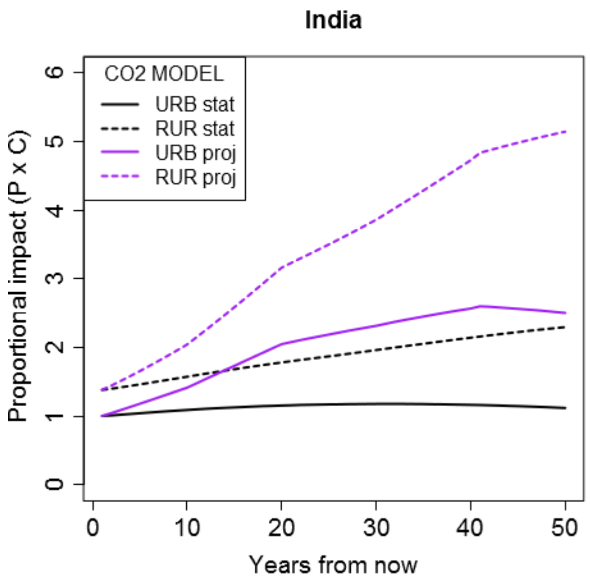

Figure 2. Static and projected emissions for urban and rural areas.

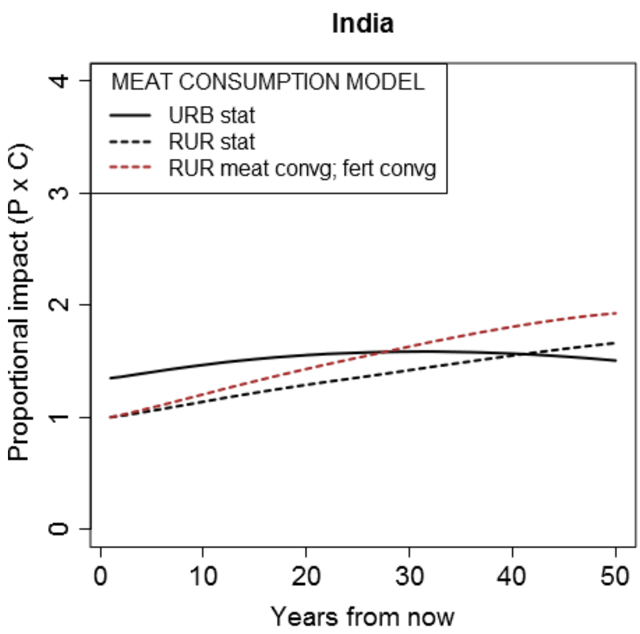

Figure 3. Static (urban and rural) and converging (rural to urban) meat consumption and fertility model.

Figure 3 depicts the static urban and rural trajectories of meat consumption impact (black lines), and an additional rural trajectory for converging trends with the urban population (topmost dashed line at t=50). The converging trend manifests steadily increasing rural meat consumption reaching the urban levels at the end of the simulation period, and likewise decreasing fertility to converge with the urban levels at time t=50 years from now. Here one can clearly see the immediate impact of increased consumption, while the effect of the change in fertility is much slower. The vegetable consumption scenario (not shown) looks very much the same as for the meat. Despite its initially higher consumption levels, the urban population has smaller overall impact in the latter half of the simulation period thanks to natural population decline.

Discussion and Conclusions

The results clearly indicate two things. First, demographic change is sluggish, meaning that lowering fertility rates take many decades to manifest as lower overall population and impact (given level consumption). Second, changes in consumption are a fast way to influence impact on the environment, in both good and in bad. Based on these conclusions and despite low urban fertility, immediate attention should be placed on actual levels of consumption.

Already in the urban space the per capita consumption of meat (Figure 3) and vegetables (not shown) overrides those in the rural domain. As the urban population grows to overtake the rural also in absolute numbers, this will have tremendous environmental consequences. Likewise for energy consumption and CO_2 emissions: urban populations currently enjoy the advantage of modern energy sources which are less polluting than the ones widely used in rural areas, however, a significant increase in per capita consumption will no doubt make this differential disappear.

Cultural considerations make the urban outlook for India slightly less gloomy than perhaps other fast-urbanising countries. Indian households hold traditionally, and up to these days, less electrical appliances than would be expected given the average affluence or income. In Indian culture, household work is often outsourced to extra pairs of hands, ranging from picking up trash to swiping the floor, doing laundry and cooking. There is therefore less need for appliances such as dishwashers and washing machines whose use would additionally suffer from electricity cuts and / or water availability. Due to cultural and religious traditions, the country also boasts the most vegetarians in the world, lessening the average environmental footprint due to meat-eating. This is unlikely to change even within a highly urbanising society, as cultural and ideological norms are slow to change, perhaps even slower than demographic change in general.

The energy source challenge for India remains. Clean energy sources incur less greenhouse gas (GHG) emissions per energy equivalent. It is therefore imperative that urbanising and developing regions bring cleanest possible modern energy within reach of a growing share of their population. Challenges for rural areas remain the coverage of energy infrastructure, which is expensive and often difficult to build not least due to topographic constraints. At a time when the world is looking to move to more sustainable, renewable energy sources, these challenges are further enhanced, due to difficulties in renewable energy storage and transmission.

One major, global challenge for the future of population and consumption impacts on the environment is poverty. Rural, as well as urban poverty cycles force people to continue to rely on primary (scarce) natural resources for their personal livelihoods, and are at the same time unable to fulfil their potential need for family planning, increasing household sizes and further the local environmental burden. Many decisions on what people eat are governed by culture, religion, and ultimately, price. Rural households typically spend a greater share of their income on basic sustenance such as food, compared to their more affluent urban counterparts, resulting generally in lower average caloric intake and especially lower levels of processed foods and meat consumption. Supporting local produce through policy interventions instead of subsidising land-intensive meat production may enable the market economy to influence people's choices more also in the urban sphere.

Bringing infrastructure for water, energy, and roads within the reach of the asset-poor, can alleviate critical pressures on the natural environment albeit nominally increasing the consumption of some resources. As witnessed through the results of this study, using more clean energy can equate to environmental benefits compared to a moderate use of the more polluting energy sources that are less efficient in terms of energy-equivalents they contain. Big infrastructure challenges remain to enable the wide-scale global use of cleaner energy with less emissions attached, however the trend to urbanise is making this development slightly more plausible.

Further work includes conducting similar analysis for other fast developing, urbanising regions such as China. We also aim to investigate the western ageing population with a focus on age-specific consumption patterns and cultural effects of consumption in migrant (expat) populations.

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Strategies for Low Carbon Humanitarian Construction

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Due to climate change, the number of refugees is estimated to reach 1 billion by 2050. Building temporary shelters and reconstructing homes even for a fraction of the future refugees would give rise to significant greenhouse gas emissions (GHG) to further accelerate the man-made climate change. Due to high degree of context-related differences in each humanitarian construction project, it would be extremely challenging to fix the maximum values for GHG emissions linked to reconstruction work or operative energy use. Instead, setting the target GHG levels based on per capita emissions in the specific country would give humanitarian aid organisations and funders a static point of reference in a path towards a sustainable built environment. This paper presents a model for robust strategic evaluation of GHG emissions associated with humanitarian construction activities.

Introduction and Background

The number of refugees is likely to exceed 1 billion by 2050 (Baird et al., 2007, p.7). This is partly due to climate change (UNISDR, 2012; Brown, 2008). Extreme weather events, sea-level rise (Hansen et al., 2013, p.6) and conflicts based on these are forcing great numbers of people to leave their homes. When the number of refugees increases, also the environmental impact of emergency aid increases – unless current emergency response practices can be improved.

In developed countries, it is estimated that the construction sector and the built environment sector generally are the dominating sources of greenhouse gas emissions. According to UN, the construction sector is globally accountable for around 30% of anthropogenic greenhouse gas emissions and around 40% of primary energy use (UNEP, 2009, p.3).

Nearly all developed countries have regulations for sustainable construction and environmental impact assessment. Several of these are linked to the *ISO 14040* standard suite for life cycle assessment and *ISO 21930 Sustainability in building construction* (ISO, 2009). European norms have also been actively developed so that the environmental assessment of buildings and construction products would be standardised and comparable (CEN, 2012). In addition, voluntary certification schemes, such as LEED, BREEAM, HQE and DGNB, are actively used in the construction and real-estate markets.

There are only a handful of instruments for environmental assessment of humanitarian construction. Pioneering contributions, such as *Checklist-Based Guide to Identifying Critical Environmental Considerations in Emergency Shelter Site Selection, Construction, Management and Decommissioning* (Kelly, 2005) or *WWF Tsunami Green reconstruction guidelines* (WWF, 2005) were useful, but rather general in their approach. Especially their coverage of issues related to climate change was limited.

Mitigating climate change needs rapid action. It can be considered as a key environmental social and economic challenge for humanity. Therefore, this paper focuses on mitigation of climate change. Furthermore, greenhouse gas emissions are chosen as the central environmental indicator, because they are of main importance in the man-made climate change (Hansen et al., 2013, p.1).

Wealthy and developed countries are main donors for humanitarian aid (Global Humanitarian Assistance, 2014). If they would apply their existing environmental goals and regulations into humanitarian aid, then the assessment of environmental impacts should be internationally standardised and promoted in chosen fields of humanitarian assistance. However, it is not known how the environmental norms prepared in the developed countries fit into the very complex humanitarian aid processes, construction of emergency shelters or temporary homes, for instance. Furthermore, the use of environmental norms may not be required in countries that receive humanitarian assistance or they may not have capacity to control that environmental standards are met directly after a catastrophe.

Therefore, a strategy is needed to guide the environmental assessment of humanitarian construction. This paper presents a draft method for setting the target levels for greenhouse gas emissions through the phases of humanitarian construction.

Material and Methods

This study was made by comparing the results from my field assessments (Haiti 2010-11 and Japan 2013), greenhouse gas calculations of transitional shelters (Kuittinen, 2013) built by the International Federation of Red Cross and Red Crescent Societies (IFRC, 2011) and energy simulations of temporary homes in Japan (Kuittinen, 2013). The results of these background studies were used as research material in this paper and are summarised below.

Background study 1: Carbon footprint of transitional shelters by IFRC

The carbon footprint assessment of eight transitional shelters was based on technical drawings and bills of quantities provided by the IFRC. Standard EN 15978 was followed in the calculation of greenhouse gas emissions. The system boundary included the production of construction materials, as other data was not available. Database ICE 2.0 from University of Bath was used for calculation of environmental impacts. The study revealed that the greenhouse gas emissions from the construction materials of the transitional shelters range from 3% to 274% of annual average per capita greenhouse gas emissions of each corresponding country53. Such a large deviation results mainly from highly differing shelter designs. It could be concluded that façade and roofing materials, especially, played important role in the carbon footprint of the studied shelters.

Background study 2: Life-cycle energy efficiency of temporary homes in Japan

The intention of this field study was to investigate the balance of operative and embodied energy and GHG emissions of refugee camps in the Sendai area, Japan. Calculations were done for the most typical transitional shelter model built by the local prefecture. Furthermore, energy simulations for these shelters were carried out by modelling the buildings in building information modelling software (ArchiCAD) and thereafter running an energy simulation with a simulation software (EcoDesigner). The building services of typical temporary homes were used in the simulation of energy supplied and emitted per month. It was concluded that the operative energy demand exceeds the embodied energy of construction materials already during a 3.5-year lifespan of the

[53] Data from World Bank, 2012.

shelters. In terms of carbon footprint, the tipping point comes later, around 4.5 years after the construction. However, when the basic shelter model was compared to alternative designs based on wood or re-used steel containers, there was much more deviation. Especially wooden shelters seem to perform well in terms of carbon footprint.

Phases of humanitarian construction

Humanitarian construction work is typically divided into three phases: emergency phase, transitional (or temporary) phase and reconstruction phase. Construction activities in the emergency phase usually consist of delivery of *emergency shelters,* if a centralised facility for emergency accommodation is not available. Emergency shelters, typically, are prefabricated tents, but in some cases only tarpaulins may be provided. The emergency phase may last from a couple of weeks to half a year. Thereafter, the emergency accommodation is ideally replaced with *transitional shelters*. They are made in more durable and may be used from 6 months to several years, depending on the case. There are international guidelines for the minimum requirements for shelters in emergency and transitional phases (Sphere Project, 2013), but they cannot always be met. After the transitional phase, the reconstruction phase follows. It includes rebuilding the homes and municipal infrastructure of the displaced population. Disaster risk reduction (DRR) strategies should be integrated into the reconstruction projects.

Results

The difficulty of setting fixed carbon footprint values for humanitarian construction

When examining the results previously referred to, it became obvious that it is not possible to recommend fixed values for the greenhouse gas emissions of humanitarian construction. There is simply too much case-specific deviation, and there are too many points of uncertainty in the assessment. Emissions associated with the production of construction products (e.g. a brick) differ in accordance with the energy that the producer used and the exact material combination of the product. Furthermore, operational energy demand may be satisfied with various sources of energy that all come with differing greenhouse gas emissions. These differing emission values depend on the efficiency of energy production and on national energy mix. Life cycle assessment (LCA) may not be feasible in humanitarian projects. A conventional, process-based LCA would suffer from large degree of uncertainty because of the lack of accurate specific or general data. Economic input-output LCA would be hard to perform as well, as the required national statistics may not be available for developing countries and may not be applicable for a developed country that has suffered a major disaster. Therefore, an alternative robust approach has been developed.

Per capita emissions as reference value

Taking the greenhouse gas emissions (GHG) per capita as a reference for comparing the global warming potential of humanitarian construction activities would provide humanitarian actors and consultants with a robust mitigation method that is context-related and therefore takes into account the variable circumstances of individual countries.

In brief, the process for mitigating per capita GHG emissions can be built with the following steps:

1) Documentation of normal annual per capita GHG values for construction in a specific country.
2) Setting a goal for the desired lowered per capita GHG emissions after the reconstruction phase.
3) Setting the maximum allowed per capita GHG peak accumulation values arising from the construction process.
4) Providing the relevant stakeholders with practical recommendations for reaching the targets.
5) Monitoring and providing required assistance during the construction process.

Steps 2–4 need to be carried out with all relevant stakeholders. Especially participatory planning practices should be utilised so that end-users would be actively engaged in the process of lowering household GHG emissions.

Ideally, the reconstructed homes should operate with GHG emissions that are lower than before the disaster. This would mean rebuilding better and with the climate in focus. Per capita GHG emissions give a static point of reference for the outcome of the reconstruction. However, the GHG peak due to reconstruction work should be kept moderate. Because of the timely importance of avoiding GHG emissions, the "payback time" of any single ton of CO2 emitted into the atmosphere should be minimised. This means that the GHG emissions from the reconstruction should soon become amortised by clearly lowered GHG emissions from the operation of the building, e.g. energy demand for heating and cooling.

The described steps can be explained with the help of the following graph. It is arranged along the phases of a generic humanitarian construction project, but may be adapted into a differing process as well.

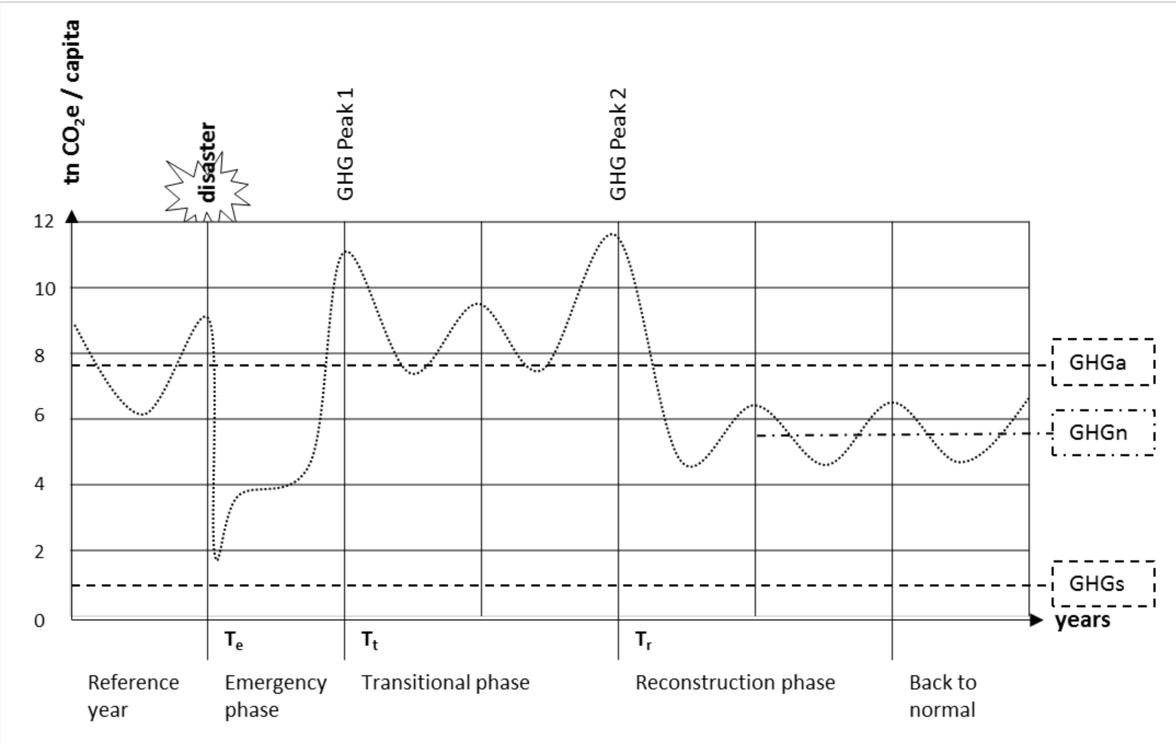

Figure 1. Per capita GHG emissions of a reference year.

The starting point in the proposed approach is formed by the annual per capita greenhouse gas emissions of the country ("GHG-a" in the graph). If it is not known how much of the national GHG emissions are caused by the construction sector, the average value of 30% by UNEP (UNEP SBCI, 2009) can provide a rough starting point for the evaluation.

The concept of "per capita" emissions and emission rights is being debated. There are alternative methods for documenting, calculating and allocating emissions (IPCC, 2007). In addition, the share of building-related GHG emissions from total per capita emissions may not be known with sufficient accuracy. Still, the existing dataset of the World Bank (The World Bank, 2012) gives a stable point for estimation.

There is seasonal fluctuation in the GHG emissions of each country. Fluctuation in household energy demand is typically caused by increased heating demand during cold periods or increased cooling demands during hot periods. The intensity of the fluctuation of household energy use depends greatly on the climate zones.

When a disaster occurs and people are displaced from their homes into emergency shelters, the GHG emissions from housing presumably sink first. This is linked to significant reductions in the availability of energy for heating, cooling, cooking or other household activities. There may be case-specific differences, however.

Reconstruction with lower GHG

References for the new, lowered per capita GHG emissions ("GHG-n" in the graph) from construction work and operational household energy use may be obtained from national climate goals, guidelines and aspirations of the funders of humanitarian construction operations (e.g. the World Bank), or be based on recommendations for sustainable level of per capita emissions. The level of "sustainable per capita emissions" ("GHG-s" in the graph) is dependent on the global goal. A candidate value could be 0.3 t. of carbon per capita, if a 450 ppmv reduction target is aimed at (IPCC, 2001). This target value, however, is very ambitious.

GHG accumulation between the disaster and reconstruction

GHG peaks ("GHG-peak" in the graph) will arise whenever new material or energy input is required for repairing shelters or when emergency shelters are replaced with transitional shelters. These peaks may be unavoidable, as the provision of adequate living conditions should not be risked. However, the magnitude of the peaks may be controlled by controlling the embodied energy and embodied GHGs of construction materials, transportation distances, machinery required on the construction site and, finally, by controlling the energy efficiency of shelters and the GHG emissions associated to the production of energy.

In addition to the GHG peaks, there are operational GHG emissions during the emergency and transitional phases. Operational GHG emissions are volatile because they are caused by the changes on the *demand side*, such as energy and material input, to meet e.g. seasonal weather changes. However, certain *supply side* changes may cause differences to operational emissions as well. For instance, changes in national energy mix are an example of the latter. After the Great Eastern Tohoku Earthquake (2011) in Japan, majority of nuclear power plants were made idle for safety reasons. The resulting shortage of energy was met with much more GHG-intensive sources of energy, such as imported natural gas.

According to calculations, GHG emissions from the construction of transitional shelters and from their energy use may be clearly higher than during reference years (Kuittinen, 2013). There may be large unrecognised potential for lowering the GHG emissions of this phase by selecting construction materials and energy supply based on their GHG intensity.

Discussion and Conclusions

Advantages of the proposed method

Choosing per capita GHG emissions is likely to give the following advantages:

- **Suitable to the humanitarian context.** It is not possible to dictate the amount of global average GHG emissions allowed for displaced people after the disaster. In addition to different climate zones, differing cultural backgrounds and consumption patterns set the stage for reference GHG values.
- **Promotes transition towards a sustainable society.** The emission reduction plan along the reconstruction process gives the society an example of rebuilding with smaller climate impacts.
- **Alternative paths to reduction of emissions**. By focusing on actual per capita emissions, it is possible to choose which of their sources can be reduced in a feasible and practical way in the given context. This gives flexibility for various humanitarian organisations or other stakeholders who participate in the construction activities. For example, if it is not possible to lower the energy consumption of transitional shelters, it might still be possible to lower the embodied energy and GHG emissions of construction materials, and vice versa.

Needs for development in the environmental assessment of humanitarian construction

The life cycle assessment of humanitarian construction operations may have significant shortcomings in the quality of data for life cycle inventory (LCI) and life cycle impact assessment (LCIA) phases. This is mostly due to the fact that documentation of the environmental impacts of a specific humanitarian construction operation cannot be obtained before the operation is completed. Even then it is highly unlikely that any specific data (e.g. energy metering from construction site or environmental product declarations of locally available construction products) would be available. Thus it is necessary to use average values for the environmental impacts of construction products. These can be obtained from various data bases. Due to its generic nature, the data from databases may have large uncertainties (Takano, 2014). This is quite likely, especially if the humanitarian operation includes the use of products or services from developing countries. Therefore, it would be important to develop databases that would take into account the context of humanitarian operations.

Next steps

A proposal for a robust method for mitigating greenhouse gas emissions of humanitarian construction has been presented in this paper. Next the proposal would need to be tested with new case studies. A potential avenue for this purpose would be to engage selected humanitarian organisations so that they could prepare documentation of suitable humanitarian construction projects in the near future. Data from the field would be very valuable in testing the proposed model. In addition to field testing, also the methodology of calculating and allocating per capita GHG emissions would need to be studied in depth and tested with case studies in order to identify the most suitable per capita emission calculation methods and existing datasets. In addition, linking the emission reduction agenda into humanitarian accountability approaches is a field to develop.

Finally, it has to be said, to avoid any misunderstanding, that controlling GHG emissions should never challenge the fundamental aims of humanitarian aid. Saving lives, alleviating suffering and maintaining human dignity must be of primary importance. They should, however, be pursued with the environment in mind.

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The Tempered Edge: Waterfront Development in an Age of Climate Change

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Urban waterfront development has followed the Baltimore waterfront model since the 1970s. This model is characterised by the formation of a thin promenade of public space with carefully choreographed event architecture, behind which lies retail, commercial and residential development. The sustainability of this model has recently been called into question by the consequence of climate change manifested in recent storm events such as Hurricane Sandy.

This paper proposes an alternative waterfront design model, one that builds environmental resilience into the typical waterfront development while still generating the expected real estate returns. The author expounds a development methodology using hydrologically modelling tools to measure the production of urban stormwater within the larger urban catchment. Modelling different scenarios, especially the implications in the increase of pervious surfaces, suggests a way in which the contemporary waterfront can become more resilient to the consequences of climate change while at the same time retaining an expected commercial return. A test case site is used to model the proposed methodology. The results show that to accommodate the hydrological consequence of climate change a radically reconfigured master plan must be adopted.

Introduction and Background

The contemporary urban waterfront was invented in Baltimore (Levine, 1987) (Millspaugh, 2003) in the 1970s. The Baltimore Inner Harbour project was driven by the proximity of the old industrial harbour to the CBD. The harbour had silted up, resulting in port operators moving away and abandoning the old port infrastructure. The new master plan was developed in the 1970s; the first buildings were completed in the late 70's. The buildings were a mixture of public and privately financed projects. The first building constructed was the publically financed Baltimore Convention Centre finished in 1979, followed by the Harbour Place mall developed by the Rouse company, opened in 1980, then the National Aquarium in 1981, Pier 6, an outdoor entertainment facility, in 1991, the Power Plant, a multi use building with bookshops, restaurants, and a gymnasium, in 1997-8, and the Port Discovery, a children museum, in 1998. Along with this building development programme was the construction of eleven hotels and two sports stadium. The buildings along the harbour edge were linked with new public space, promenades, squares, and parks. The success of the Inner Harbour development has been aggressively promoted with claims that the project receives more visitors a year than Disneyland, produces $786 million dollars a year in revenue and has generated 16,000 jobs. The Baltimore model has become codified, especially in North America and has led to the development of many waterfront projects around the world (Breen & Rigby, 1996). The development demonstrates two critical urban influences; the first, a particular planning morphology developed by New Urbanism, the second, real estate planning especially the use of floor area ratios (FAR). Most waterfront master plans follow an urban model developed by the new urbanist movement. (Kunstler, 1994). Based on traditional American urban settlement patterns, new urbanist city planning uses a grid street layout with public spaces determined by a classical urban typology of square, park, and promenade, all architecturally defined by buildings. The real estate requirements of contemporary urban development are usually expressed as GFA (gross floor area) ratios divided between different real estate functions, typically, retail, entertainment, commercial and residential (Ratcliffe & Stubbs, 2013). These commercial requirements can be expressed in different combination, in simple block models or combinations within blocks. Another way of measuring the expected yield of a real estate development is through a floor area ratio (FAR). This is a simple ratio of the area of the site to the built footprint. (Fu & Somerville, 2001)

The development of the contemporary waterfront is an extremely successful and lucrative model of urban growth (Breen & Rigby, 1996), Three important examples of waterfront development that show the development of the Baltimore model are; the London Docklands, the Melbourne Docklands and HafenCity. The London Docklands development was initiated in the early 1980s (Foster, 1999) ("London Dockland Development History," 2011). The Melbourne Docklands redevelopment initiated in the mid 1990's is a comparable project to the London Dockland development. The site, the old Melbourne docks, is to the west of the Melbourne CBD. The impetus behind the development was driven by many of the same factors that drove the London Docklands development, the abandonment of the docklands in the 1960's with the advent of containerisation and the old docks location near the commercial heart of Melbourne (Authority, 2000; Dovey, 2005). The HafenCity, Hamburg, Docklands redevelopment project was initiated in the early 2000's and is planned to finish in the 2020's. The master plan for the development of the docklands was subject of an urban design competition in 1999, the winners were a joint Dutch/ German team, Kees Christiaanse /ASTOC (Bruns-Berentelg, 2006). HafenCity is an on-going project that demonstrates a number of similarities with previous dockland redevelopments. The building of the new urban layout is based on a grid pattern, the use of a building programme to define urban space, and the treatment of the waterfront promenade as a generic public space, clearly links HafenCity to other dockland developments (Schubert, 2010). However the development process in these three examples, and the hundred more that have been built around the world, ignore the serious environmental problems that will be caused by climate change. The most common problems are the threat of sea-level rise and the increase in discharge of contaminated stormwater at the edge of the waterfront development. These problems are well recognized and the techniques for their alleviation and remediation are equally well recognized; the increase in contaminated stormwater can be treated and retained in constructed wetlands, (Shaver & Consultants, 2000) and the impact of sea level rise as storm surges can be ameliorated through the establishment and restoration of littoral vegetation and reef formations as buffer zones. (Feagin et al., 2010) number of speculative design projects has been developed to address the implications of these issues. Probably the best known one is; Rising Currents: Projects for New York's Waterfront, an exhibition and publication in 2010 curated by Barry Bergdoll and the Museum of Modern Art (Oppenheimer, Barry, & Rodin, 2011). Responding to the challenge that New York faces with sea level rise due to climate change, the curator invited groups of inter disciplinary professionals to put forward design proposals that would make New York more resilient to the rising tide. The subsequent design work draws from the insights of urban ecology and certain soft engineering techniques such as artificial wetlands, reefs and day lighting stormwater systems to develop a system of amelioratory and remediatory regimes that will protect the New York littoral.

Notwithstanding this work, civic authorities and private developers have met many of these serious environmental problems with surprising equanimity. In this paper I question the accepted real estate model for a waterfront development, a gridded plan with a littoral promenade, is a proven and reliable model of real estate development with a well established development process and knowable investment and return timelines (A. Gordon, 1997). This model represents a powerful and knowable formula that such difficult factors such climate change are either ignored or only conceded as exigencies in the development process. (Auckland, 2013)

The contention offered by this paper is that the threat of climate change for the waterfront site will not be addressed until and unless a planning methodology can be developed that allows for the necessary remediation programmes while ensures a similar or better commercial development.

Materials and Methods

The effects of climate change on the waterfront site can be ameliorated by three measures structural stormwater control, remediation of urban soils, and the reconstruction of native flora.

Structural stormwater system

There are a number of devices and structural interventions that make use of natural systems to both improve stormwater quality, attenuate and retard stormwater flow. These devices are hybrid systems, a combination of conventional architecture or urban construction such as roofs, pavements, curbs, parks, and landscapes; meadows, wetlands, and stream margins. Green roofs are used to minimize runoff from conventional roof surfaces. A green roof can help to delay and reduce the runoff from a storm event. This helps to divert the volume of water that would have been treated by a conventional stormwater system (Carter & Rasmussen, 2006). Water quality can also be improved through vegetation filtering out pollutants and the soil mix binding pollutants (Cantor, 2008). Buffer strips are usually grassed areas adjacent to impervious surfaces, typically roads and car parks over which run off will travel. Buffer strips are effective at removing sediment and some pollutants. Swales work like conventional curb and channel systems but with open vegetated channels. The vegetation acts in two ways, one to attenuate the flow of stormwater the other to remove a variety of pollutants and trap sediments (Davis, Stagge, Jamil, & Kim, 2012). Bio retention systems actively treat stormwater in-situ by filtering the run off through vegetation and fine media layers. The effect is to slow down runoff flow and to improve stormwater quality (Roy-Poirier, Champagne, & Filion, 2010) The vegetation layer acts to remove larger sediment while the below ground layers trap certain pollutants. Constructed ponds are dammed water bodies with a low range of water level movement and marginal vegetation. Ponds help trap sediments and pollutants in silt layers (Moore & Hunt, 2012). Ponds are also able to uptake some pollutants through phytoplankton. Constructed wetlands are contained shallow water systems that regularly fill and empty with aquatic vegetation (Malaviya & Singh, 2012). Wetlands trap sediments and pollutants and the vegetation helps to uptake-dissolved pollutants (Wong & Engineers Australia. National Committee on Water Engineering., 2006).

Soils

Soils are often in the most highly compromised state in the urban environment. Subject to the construction of urban infrastructure, their structure is often highly modified. The composition of many urban soils are often the result of extensive filling operations, where soils from different regions are mixed and compacted to form new city territory (Pouyat, 1999). Urban soils are often subject to pollution by highly toxic contaminants released from industrial zones over many years. Notwithstanding these major problems, an understanding of urban soils is critical in any attempt at environmental rehabilitation. Urban soils are a medium for urban flora, providing both nutrients and water for growth. The rehabilitation and protection of urban soils are critical in any attempt at environmental remediation. The structure and composition of soils in a waterfront catchment has an important effect on hydrological systems. Looking at the intersection of terrestrial and aquatic ecosystems (Critical transition zones, CTZ) researchers (Levin et al., 2001) have identified the way soils regulate hydrological flows. They have located the ways in which soils in CTZs can influence infiltration, leaching, run off and erosion. The authors go on to suggest that soil biodiversity influences hydrological pathways and that soil biodiversity is linked to larger environmental factors.

Vegetation

Urban vegetation can play an extremely positive role in regulated the management of both stormwater (Booth, Hartley, & Jackson, 2002) and sea level rise. The authors found that the planting of large scale trees within a urban infiltration system not only reduces selected chemical concentrations found in stormwater; reducing nutrients and removing pollutants. They also contributed to the evaporation and transpiration of rainfall and aided in the amount of soak water infiltration.

Organisational regimes / increased sustainability

The different states of an urban ecosystem can be connected by increasing the viability of an urban ecosystem through increasing species biodiversity and by the optimisation of biophysical processes that are essential to its functionality. Measures to increase biodiversity in one state are inalterability linked to improvement in conditions for another. In *Measuring Landscapes* (Leitão, Miller, Ahern, & McGarigal, 2006) a number of broad guidelines for making an urban ecosystem sustainable are advanced. The first is to maintain large existing patches of native vegetation. This measure helps to preserve the ecological viability of existing indigenous flora and leaves open the possibility to increase the area of native flora. The model that Leitao et al describe helps to conceptualise the spatial pattern of a functioning urban eco system and provides techniques to increase the sustainability of the ecosystem.

An Alternative Waterfront

Case Study Wynyard Quarter, Auckland, New Zealand.

To explore the effect of how these remediation regimes could contribute to the development of a new waterfront planning methodology, a test case site; the Wynyard Quarter in Auckland, New Zealand will be explored. This case study will investigate how structural stormwater remediation and sea level rise remediation measures might be used to determine the design of a new waterfront in an inner city catchment.

The Site

The Wynyard Quarter is situated on the western side of the Auckland CBD, New Zealand between the Westhaven Marina and Viaduct Harbour. The Wynyard Quarter started life as reclamation in the 1930s; the site was used for warehousing, the fishing industry and most importantly as an industrial fuel store. This western zone has been undergoing a slow redevelopment from an industrial wharf and tank farm to a new consumerist waterfront over the last 20 years

Peter Walker, (Walker, 1996) an American landscape architect, was commissioned in 2003 to develop a master plan. The basis of this plan was the establishment of two axes that connect the site to the city; a north/south axis from the existing Victoria Park to the northern tip of the reclamation and a west/east axis from the Wynyard Quarter to the CBD via Quay Street. This plan was modified by a local Auckland architectural practice, *Architectus*, (Architectus, 2007) in a report prepared in 2007. The proposed building programme is contained in the indicative framework section of the report. The Wynyard Quarter is approx. 388888 m^2. Of this area 580000 m2. is to remain as existing marine related industries, mainly on the Westhaven marina side. The main body of the site is a development zone of approximately 210000 m2. The rest of the site is to be allocated as public space. The development site is broken into three zones; the Point Precinct at the northern end of the site is zoned mainly as residential. The middle zone, the Jellicoe Precinct, has a more complex social and building programme, which relates to its role as part of a structural urban axis linking the Wynyard Quarter to the CBD. The Central Precinct is the largest zone from Jellicoe Street to Fanshawe Street, a third of this site is owned by another party, Viaduct Holding Group. This zone is devoted to mostly residential and commercial use with small percentage of retail. The total build out for the whole quarter is approximately 1.1 million square metres.

The two main areas of waterfront development are the North Wharf, the Wynyard Quarter end of the west/east axis linking the site to the city and the Point Park, the northern end of the north/south axis, linking the site to Victoria Park. The North Wharf consists of a two east / west thoroughfares, the northern one, pedestrian, the southern one, a road that sandwiches an active zone of restaurants, playgrounds, bars and public spaces. The northern zone runs adjacent to the sea forming a pedestrian promenade. The North Wharf precinct was completed in time for the 2011 Rugby World Cup.

Environmental Issues

The Wynyard Quarter has a number of potentially serious environmental problems due to climate change. The discharge of contaminated stormwater is a major issue for the Wynyard Quarter. While small-scale stormwater remediation wetlands have been installed, these measures only address the local effects of the new urban configuration. The stormwater discharge from the larger Freemans Bay catchment is concentrated in a 4m-diameter pipe with a single discharge point under the North Wharf. After heavy downpours there is highly visible harbour contamination that leads to toxic sedimentation around the wharf area. This problem will only be exacerbated by the expected storm events due to climate change. The local stormwater outlets for Wynyard Quarter are on average one metre above the mean high tide level. With the anticipated sea level rise of one metre these outlet will become blocked. In the event of a storm event in the Freemans Bay catchment the resulting stormwater will be unable to discharge, this will resulting in wide spread flooding. The site is also vulnerable to flooding from storm surges.

Remediation Methodology

To make the Quarter resistant to climate change a hydrological analysis of the catchment is undertaken with an end of pipe remediation wetland proposed for stormwater treatment and detention. Storm surges are mitigated through the provision of a newly vegetated buffer on the littoral linked to the planting of a 60000 m2 ecological patch to ensure a vigorous, healthy and resilient ecology. The Wynyard Quarter can be rescaled as part of a larger urban catchment system, the Freemans Bay catchment. This site is defined by four ridge roads; on the western boundary, St Maries Bay Road, Ponsonby Road, and K Road along the southern boundary and returning on the eastern side along Hobson Street

Stormwater Production and Treatment

The Freemans Bay catchment covers an area of 2440000 m2 of which 72.7% is an impervious surface (1780000 m2). The impervious surfaces are made up of building, roofs (640000m2) and roads, driveways and footpaths (1140000m2). This leaves 27.3% (660000m2) as pervious surfaces made up of, parks, lawns and vegetated buffers. The result is the production of a large amount of storm water flowing under the Wynyard Quarter to discharge at the sea edge. The pipe outlet sits below the high tide mark and is frequently filled with seawater. This results in the stormwater backing up to cause some surface flooding, especially when storm events coincide with high tides. During a two-year storm event, the impervious surfaces of the Freemans Bay catchment produces 132, 940m^3 of water run off.

In accordance with Auckland Council's TP10 (Council, 2003) a third of stormwater volume should be collected for treatment resulting in a first flush water volume of 44, 300m^3. A constructed wetland can be used to treat the contaminated first flush.

Equations (TP10 Chapter 3.5.1)	
$S = ((1000/CN) – 10)25.4$	$Q_{24} = (P_{24} – I_a)^2 / ((P_{24} – I_a) +S)$
$V_{24} = 1000Q_{24}A$	$V_{ff} = 0.3V_{24}$

Catchment Impervious Area: 1.78km^2	Catchment Pervious Area: 0.66km^2
CN: 98 for impervious surfaces I_a: 0 for impervious surfaces P24: 75mm (TP108)	CN: 61 for lawns I_a: 5 for pervious surfaces P24: 75mm (TP108)
$S = ((1000/98) - 10)25.4 = 5.18$ $Q_{24} = (75)^2/(75+5.182) = 70.15$ V_{24} = 1000 x 70.153 x 1.78 = 124, 875 V_{ff} = 0.3 x 132 940 = 37, 462m^3	$S = ((1000/61) – 10)25.4 = 162.4$ $Q_{24} = (75 – 5)^2 / (75 – 5) + 162.4 = 21.1$ V_{24} = 1000 x 21.1 x 0.66 = 13,915 V_{ff} = 0.3 x 13,915 = 4174m^3
V_{ff} Total = 41, 636m^3	

Auckland Council TP108 details wetland construction calculations. These calculations are presented as a guide based upon regulations in TP108. Banded bathymetry is the preferred wetland design method. This features a wetland with 0-1m deep storage pools, these should account for 40% of the surface area, with 60% of the wetland area 0-0.5m deep. The forebay can be up to 2m deep to slow the flow of incoming water and should store 15% of the over all volume of the wetland. The wetland size calculations presented here are all derived from these conditions. For a wetland to effectively treat the stormwater flows from the existing Freeman's bay catchment, a wetland would have to be sized accordingly. For a wetland to effectively treat the 41, 636m3 of water run off during a two-year storm event, the wetland must be approximately 540000 m2 (fig. 1)

Fig. 1

To test the model, two extra iterations were explored.

Remediation of Stormwater – Reduce impervous surface in the Wynyard Quarter

If the proposed wetland were located at Wynyard Quarter, it would occupy about 15% of the site. How much smaller would the wetland be sized if we reduced the impervous surface in Wynyard Quarter to 100% pervious ? From the calculations, the wetland area is reduced by 1.85%, giving a wetland size of approximately 530000 m2. Balancing the commercial imperative for the development of the Wynyard Quarter site with the necessity to treat the stormwater from the Freemans Bay catchment the results suggest that varying the ratio of pervious to impervous surface in the Wynyard quarter site will have little impact on the size of the treatment wetland.

Remediation of Stormwater – Substitute Green Roofs for all building in the Freemans Bay Catchment

The second test assumes all roofs in the catchment, including those within Wynyard Quarter, would be replaced with green roofs, rendering these as effectively pervious surfaces. The results show (see appendix) that the end of pipe wetland can be reduced to 31.5% of the original wetland size. This shows the effectiveness of green roofs in the mitigation of stormwater runoff.

To summarise, to remediate the stormwater from the Freemans Bay catchment with an end of pipe wetland requires a wetland of 540000 m2. If the Wynyard Quarter were to be 100% pervious, the size of the wetland is reduced by 1.5% to 530000 m2. If all building within the Freeman's Bay catchment were to have green roofs, the size of the wetland is reduced by 31.5% to 370000 sm2

Sea Level Rise

To protect against expected sea level rise and associated storm surges a 30m buffer zone at the edge of the development to absorb storm surges is proposed (fig. 2) To ensure this buffer remains in good ecological health the buffer is linked to the construction of a 650000 m2 ecological patch. This patch, the size and planting is based on the Meurk and Hall model. (Meurk & Hall, 2006). To understand the necessary size and connection of the patch a study of the location and types of surrounding parks is made. The only urban park within 1km of Wynyard Quarter is Victoria Park. Though there are large trees around the open park, these are not substantial enough to be considered a 15600 m2 medium patch. Within a 5km radial area, there are some parks large enough to be 650000 m2 core patches. On the isthmus, there are 4 parks within 5km; these are Auckland Domain (2.7km), Mt Eden (3.9km), Western Springs (4.6km) and Cox's Bay Reserve (2.8km). All of these parks are made up of open space and native trees. Across Auckland Harbour, there are two patches within the 5km radius; these are, Leroy's Bush Reserve (3.5km) and Kauri Point (4.2km). These reserves are both made up of mostly native species with some open space. With the construction of the Wynyard Quarter ecological patch an important link for native flora can be made in an inner city site. This helps to increase the ecological health of the proposed vegetation programme.

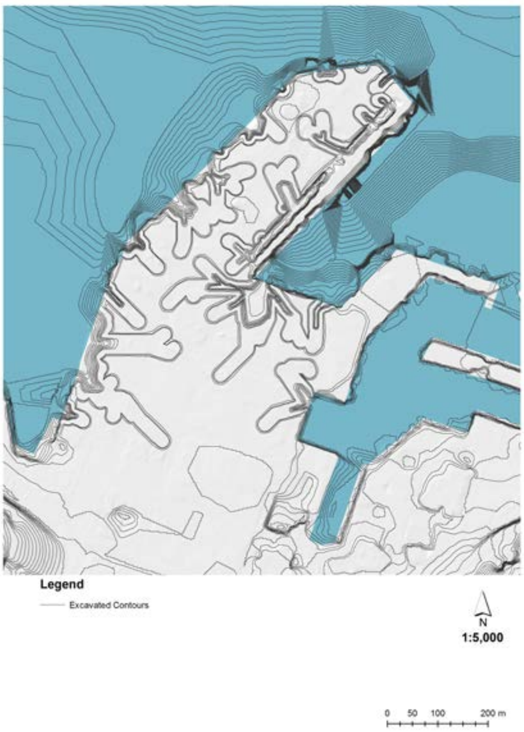

Fig. 2

Bringing together the three-remediation projects, the remediation wetland, the storm surge buffer and eco patch. The integration of a coastal surge defense with the stormwater treatment operation generated the idea of a dispersed wetland network rather than a one large central pond. Existing over land flow paths on the site where determined through GIS mapping to show on-site water movement. These overland flow paths were buffered to 30m initially as a waterway protection measure. The resulting area, 120000 m2 was large enough to collect stormwater and become a dispersed wetland system. The overland flow paths that drained directly to the harbour were selected to become remediation wetlands. These areas were excavated to below the mean tide level where applicable. Some buffered overland flow paths were too small to excavate to below high tide, though all buffered overland flow paths were excavated as wetlands.

The local high tide rises to 1.5m, so each wetland was excavated to a lowest level of 2.0m. Some wetlands were excavated below the high tide level to provide a greater coastal edge and the opportunity for coastal ecological restoration. With the overland flow paths excavated, approximately 60% of the excavated area will be fresh water wetland, with the coastal edge reserved for restoration. The fresh water wetland ground level is at 2.5m with 1m deep pools excavated to 2.0m. This is high enough to prevent the tide flowing in to the wetlands, though with sea level rise, these environments may become brackish, rather than fresh water. Each wetland is enclosed up to 3m along the coast to prevent storm surge overflowing in to the wetlands.

Results

The implication of the dispersed wetland network for remediation of sea level rise

The excavation of the wetlands resulted in 116, 320m^3 of soil being removed. By filling the remaining site the existing ground level of 3.0m above mean sea level can be raised to 3.7m. This raises the ground level to be higher than the expected sea level rise, a new high tide line of 2.5m. The construction of a 30m wide buffer around the coastline as public space and coastal restoration and a 65000 m2 eco-patch results in storm surge protection and an increase in local bio-diversity and urban ecological connections. (fig.3)

Implication of the environmental remediation on the infrastructure layout

Following the excavation and laying out the new ecological infrastructure, the conventional infrastructural elements are laid out. This includes a 4 lane main road to run the length of Wynyard Quarter and a central stormwater pipe linking to the existing network to disperse stormwater into the new wetlands system. Given the layout of the wetlands, and the underground nature of the stormwater pipe, the piping through Wynyard Quarter below 4m must be a sealed system. This will allow the pressure of the flowing water to push the water from underground to the top of each wetland. Larger wetlands have more than one inlet to drain a greater portion of the stormwater, while smaller wetlands have only one inlet. This will help to evenly spread stormwater across the wetlands for effective treatment.

Fig 3

Implication of the environmental remediation on the building programme

Into this reconfigured hydrological landscape, the building programme from the 2007 Wynyard Quarter plan can be inserted. (fig.4) The total GFA proposed is; residential/retail, 76,701.00 m2 commercial 586,585.00 m2 and residential, 453,661m2. giving a total build out of 1,115,947.00 m2. The building programme is located on the site to avoid the overland flow paths and the coastal edge. The total area left for possible development after privileging the hydrological conditions is approx. 118000m2. By reclassifying the blocks according to area, larger blocks can be identified as possible building footprints. A spinal block in the Point Precinct zone and two large blocks within the Central Precinct area can be identified as building sites. The total footprint of these blocks is 52,000 m2. Extruding the blocks by taking the GFA building programme of the WQ at 1,115,947.00 m2. and dividing it by 53000m2 gives an average height for the building blocks of 23 stories or 63m. The result is a spine of 7 mini blocks along the Point Precent with two mega blocks on the west and an east side of the body of the site; the remainder of the site is an undifferentiated field, open to the possibilities of a new social programme.

Discussion and Conclusions

The resulting 'urban form' of the extruded building mass suggests that the constituent parts of the new city have become amalgamated into one form through the manipulation of the FAR, in effect, the waterfront city has become one connected building.

Precedents for this kind of urbanism can be found in the 1960s megastructure movement, and in its a more contemporary manifestation landform building, Megastructure was an urbanist/architectural movement in the 1960s (Banham, 1976). Architects attempted to resolve the problem and issues of the contemporary city through the agency of a single (very large) building. Fumihiko Maki defined a megastructure as 'a large frame in which all the functions of a city or part of a city are housed….' There are many, unbuilt, project which help to define the urbanist features of this ideology, Friedman's Citee Spatiale and Constant's New Babylon suggest an open frame, which is explored and colonised by the cities inhabitants. Le Corbusier's plan Obus in Algeria, a proto megastructure from the 1930s, combined infrastructure, like services and roads with housing to form a linear city form. This model was developed in the planning of Cumbernauld new town in Scotland. In Japan the metabolism movement developed utopian megastructure most famously Kenzo Tange 1960 Tokyo Plan. Tange proposed a massive linear urban form organised along a three-speed freeway spine. The megastructure avoided demolition existing city of Tokyo by building on Tokyo Bay.

In a more general sense the hydrological landscape of the new Wynyard Quarter brings to mind an important urban idea, the city in a landscape. Precedents for this kind of urban development, a dialogue between building and landscape to form a new city form are common in the history of 20st century urbanism. There is a discernable trajectory starting with the invention of the garden city in the book, *Garden Cities of To-morrow* written by Ebenezer Howard in1898 and the building of the first garden city in Letchworth, Herefordshire in 1903. The publication and the city form the kernel of a movement that will influence a distinct urban form in the 20th century. Distinguished examples range from Onkel Toms Hutte, built in the Berlin suburbs in 1925 and Radburn, a cluster garden city built in New Jersey in 1929. The most famous outcome of this movement is the post war American suburb, an urban model that has spread through out the world. The implication of Howard's ideas on more conventional higher density city planning can be found in a project like Le Corbusier City for Three Million, a paper project designed in 1929. In the city plan Le Corbusier mixes a number of urban planning tropes; 19th century English parks, Beaux Arts urban planning, and the American skyscraper, to produce a new urban type, the residential tower in a park setting.

This brief exploration of different urban histories of the 20th century demonstrates that there are alternative types of urban development that could be put forward as relevant urban paradigms. By putting aside the accepted tropes of contemporary waterfront design, an unprejudiced relationship may be found between the demands of real estate development and the requirement for climate change remediation.

Fig 4

Conclusions

This paper proposes a new trajectory of waterfront urban design from the Baltimore model to a new waterfront development that is resistant to climate change. From a highly urbanized, highly programmed, commercial promenade to a new kind of urban space.

Morphologically the Baltimore waterfront model offers a simple dichotomy; public space is usually confirmed to a littoral, a narrow band between the water and the building. Private space is confined to the interior within a real estate driven matrix of commercial, residential and retail development. The public space is treated as a promenade, a linear walkway along which the public *passeggiata*. Public and semi public buildings are often located in this zone to encourage destination walking with eating and drinking along the way. The water is presented as a passive spectacle to be gazed upon. While the interior of the waterfront project may have some public space, usually the street, the desire here is for real estate maximization. Environmental problems are concealed in the Baltimore model, contaminated earth is either removed or capped, contaminated stormwater is diverted or holding tanks are installed. Rising sea level is a more recent phenomenon and would seem to present a more intractable problem.

The alternative waterfront plan presented in this paper exposes this typological straightjacket through the careful yet necessary excavation of the site and the associated environmental conditions. By privileging well-known remediation techniques the designer is able to rethink the over 30 year old prescription of waterfront public space. No longer a narrow band along the waterfront, public space and the infrastructure of environmental remediation interconnected. A wetland becomes a common, a park becomes an ecotone of native planting. The raw metrics of the real estate programme, critical to the success of any waterfront development, are retained. But the conventional new urbanist formula of a street grid with the building occupying the whole block is abandoned. A looser relationship of programme to GFA is explored where the building footprint shrinks while building heights are allowed to expand, ensuring the expected real estate return.

While waterfront development retains its commercial allure, the clear and present threat of climate change must drive the next stage of the design of the urban waterfront. A reconsideration of the conventional urban forms, driven by the remediation of environmental challenges can provide a way forward for this most valuable trope of real estate development.

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What are the Green Export Opportunities for the Caribbean?

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A green economy is one that focuses on the harmonious interaction between humans as well as nature and attempts to meet the needs of both simultaneously. This approach has been put forward as a viable pathway towards sustainable growth and development. To move the green agenda forward, one would need to ensure that sufficient support is provided to the new businesses and industries that are likely to emerge. The potential green business areas that are likely to develop should inform a green growth strategy. This study therefore attempts to provide an assessment of various green businesses and their potential suitability to small island states in the Caribbean.

Keywords: Green economy; Revealed Comparative Advantage Indices; Small island states

Introduction

Sustainable development is usually defined as development that meets the needs of the present generation without compromising the prosperity of future ones (World Trade Organization, 2011; Brundtland Commission, 1987). Related to this concept is the notion of the green economy: a green economy is characterized by substantially increased investments in economic industries that build on and enhance the earth's natural capital or reduce ecological scarcities and environmental risks. These investments are driven by, or supported by, national policy reforms and the development of international policy and market infrastructure. Hence, green investment not only minimizes issues related to scarcity but also reduces countries' overall opportunity cost since a plethora of existing policy options, such as public investment are at governments' disposal and can be enacted without abandoning any previous goals of sustainable development or poverty eradication. (UNEP, 2011)

Given the nature of Caribbean economies (small and open), growth must inevitably be export-led, at least in the long run (World Bank, 1988). Supporting studies by Frankel and Romer (1999) recognise the link between new potential export markets and improvement in standards of living. Indeed the authors find that a rise of one percentage point in the ratio of trade to GDP increases income per person by at least one-half percent; a significant result when the goal of sustainable development is at hand. The work by Frankel and Romer (1999) iterates trade appears to raise income by spurring the accumulation of physical and human capital and by increasing output for given levels of capital. Others publications infer that small island states, such as those in the Caribbean, should diversify their portfolio in order to achieve sustainable growth, citing terms of trade as a potential avenue to secure economic welfare across generations. (Moore, et al., 2012)

By combining these findings with the need for a green agenda, a premeditated green export regime change that will promote environmentally and socially sustainable consumption and production seems beneficial. As Stern (2007) notes, to ignore possible green economic transitions is to hinder economic growth. Lack of resources is our biggest problem and we do not do our standard of living any justice by not incorporating renewable ones into our decision-making.

Different organizations and policymakers have diverse definitions on what constitutes green goods and services. These industries primarily include renewable energy, low-carbon transport, energy-efficient buildings, clean technologies, improved waste management, improved freshwater provision, sustainable agriculture, forestry, and fisheries. However other literature provides alternative and more in-depth classification methods that are useful for policy implementation. For example, The Republic of Korea's Green Stimulus (World Bank, 2010) has five distinct sectors. These are: i) Climate change sector, ii) Energy source technologies, iii) Efficiency Improvement technologies, iv) End-of-pipe technology, v) R&D in Virtual Reality.

The Bureau of Labour Statistics (BLS, 2012) categorizes green goods and services into five groups:

- production of energy from renewable sources;
- energy efficiency;
- pollution reduction and removal, greenhouse gas reduction, and recycling and reuse;
- natural resources conservation; and,
- environmental compliance, education and training, and public awareness.

There have been attempts to provide an empirical analysis of international trade patterns in the Caribbean. Lewis-Bynoe and Webster (2001) examined international trade and comparative advantage in the Caribbean for the year 1994. Similarly, Lorde, Francis and Alleyne (2009) examined the export performance on CARICOM countries, through the use of RCA indices, for the years 1992–2006. The absence of a clear definition and the unavailability of comparable data on services have contributed to limited research in comparative advantage in services (Seyoum, 2007). None of the papers above, however, take into account the sustainability or the green characteristics of these export industries.

The paper contributes to the literature in three main areas. First the study provides an assessment of the potential export opportunities for the Caribbean in various areas through the calculation of comparative advantage indices for 10 countries in the region. Second, based on the results above, a discussion of the similarity of green exports was also provided to consider the possibility of regional integration. Third and final, the results of the study provide an input into the potential benefits that Caribbean countries could expect from multilateral liberalisation in the trade for green goods.

The remainder of the paper is structured as follows. Following the introduction, section 2 outlines the methodological approached employed in the study to identify green export opportunities. Section 3 summarises the main results and provides a discussion of the implications of these findings. Section 4 concludes and provides some recommendations on the way forward.

Methodological Approach

As discussed in the previous section, the list of potential green goods and services is both long and contentious. To avoid providing an arbitrary list of potential business areas or even worse a long exhaustive list that is not necessarily relevant to the Caribbean situation, an analytical approach for evaluating business areas is employed. A schematic representation of the modelling approach is provided in Figure 2. The approach utilised needs to take into account some universe of green business opportunities. Given the focus of this paper on export opportunities, the proposed WTO (2011) list of green goods is a good starting point.

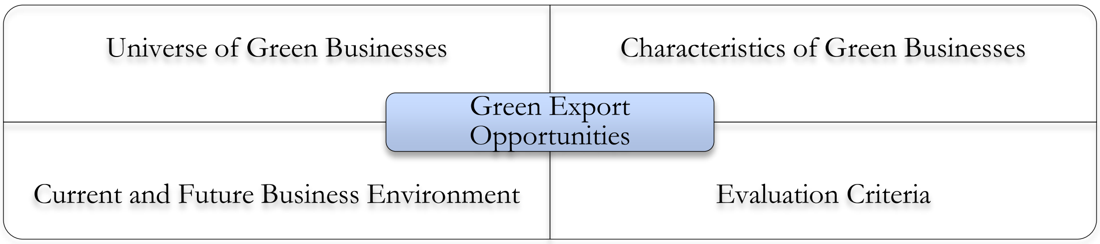

Figure 4: Schematic Representation of Business Opportunities Process Model.

One approach (evaluation criteria) that can be employed to identify potential green business export opportunities is to calculate indices of revealed comparative advantage (Balassa, 1986; Balassa, 1989). These indices provide a simple measure of the extent to which the country or regional group is more specialised in a particular area of goods relative to another. The most popular comparative advantage index is the revealed export advantage (REA):

$$REA = \frac{X_{ij}/\sum_{j=1}^{J} X_{ij}}{\sum_{n=1}^{N} X_{nj}/\sum_{n=1}^{N}\sum_{j=1}^{J} X_{ij}} \quad (1)$$

where X_{ij} is the country *i*'s exports of good *j* and X_{nj} are the exports of country group *n*. The country is assumed to have a revealed comparative advantage if $REA > 1$ and a revealed comparative disadvantage if $REA < 1$.

Vollrath (1991) proposes three alternative indices: (1) relative trade advantage (*RTA*); (2) the logarithm of the relative export advantage (ln *REA*), and; (3) the revealed competitiveness (*RC*). These three indices are provided below:

$$RTA = \frac{X_{ij}/\sum_{j=1}^{J} X_{ij}}{\sum_{n=1}^{N} X_{nj}/\sum_{n=1}^{N}\sum_{j=1}^{J} X_{ij}} - \frac{M_{ij}/\sum_{j=1}^{J} M_{ij}}{\sum_{n=1}^{N} M_{nj}/\sum_{n=1}^{N}\sum_{j=1}^{J} M_{ij}} \quad (2)$$

$$\ln REA = \ln\left(\frac{X_{ij}/\sum_{j=1}^{J} X_{ij}}{\sum_{n=1}^{N} X_{nj}/\sum_{n=1}^{N}\sum_{j=1}^{J} X_{ij}}\right) \quad (3)$$

$$RC = \ln\left(\frac{X_{ij}/\sum_{j=1}^{J} X_{ij}}{\sum_{n=1}^{N} X_{nj}/\sum_{n=1}^{N}\sum_{j=1}^{J} X_{ij}}\right) - \ln\left(\frac{M_{ij}/\sum_{j=1}^{J} M_{ij}}{\sum_{n=1}^{N} M_{nj}/\sum_{n=1}^{N}\sum_{j=1}^{J} M_{ij}}\right) \quad (4)$$

For all three indices, positive values would indicate that the country has a revealed comparative advantage. It should be noted that all the indices outlined above can be distorted by government policies and other interventions. This caveat should be considered when interpreting the results. All values for commodity exports and imports are obtained from the United Nations (UN) Comtrade Online Database using the six-digit HS2002 classification and trade data over the period 2006 to 2009 [54]. The countries covered in the database include the Bahamas, Barbados, Belize, Cuba, Dominica, the Dominican Republic, Guyana, Jamaica, St. Vincent and Trinidad and Tobago.

Identification of Potential Green Export Opportunities

In order to assess the consistency of the revealed comparative advantage indices, Table 1 provides the pairwise correlation statistics between the four indicators. In general, the indicators are all positively correlated: if one comparative advantage index suggest that the country has an advantage for a particular good, the other indicators are also likely to provide a similar result. In addition to the positive relationship, for virtually all of the bivariate correlation statistics the value was greater than 0.7 indicating a high level of consistency, while more than 50 percent of the statistics were greater than 0.9.

[54] The HS codes for the universe of green goods is 250300, 271011, 271019, 271111, 271112, 271113, 271114, 271119, 271121, 271129, 281810, 281820, 28183, 290911, 290919, 290920, 290930, 290941, 290942, 290943, 290944, 290949, 290950, 290960, 291411, 291412, 291413, 291419, 291421, 291422, 291423, 291429, 291431, 291440, 291450, 291461, 291469, 291470, 382490, 390210, 390220, 390230390290, 390799, 390910, 390920, 390930, 390940, 390950, 391110, 391190, 391211, 391212, 391220, 391231, 391239, 391290, 392010, 401699, 450410, 460120, 470710, 470720, 470730, 470790, 530310, 530410, 530490, 560314, 560710, 560721, 560811, 560890, 630510, 691010, 701931, 730300, 730410, 730421, 730431, 730439, 730441, 730449, 730451, 730459, 730490, 730511, 730512, 730519730520, 730531, 730539, 730590, 730610, 730620730630, 730640, 730650730660, 730690, 730711, 730719730721, 730722, 730723, 730729, 730791, 730792, 730793, 730799, 730820, 730900, 731010, 731021, 731029, 731100, 732111, 732190, 732490, 732510, 732690, 761100, 761290, 761300, 840211, 840212, 840219, 840220, 840290, 840310, 840390, 840410, 840420, 840490, 840510, 840590, 840610, 840681, 840682840690, 840790, 840890, 840991, 840999, 841011, 841012, 841013, 841090, 841111, 841112841121, 841122, 841181, 841182, 841191, 841199, 841210, 841221, 841229, 841231, 841239, 841280, 841290, 841311, 841319, 841320, 841330, 841340, 841350, 841360, 841370, 841381, 841382, 841391, 841392, 841410, 841430, 841440, 841459, 841480, 841490, 841510, 841581, 841610, 841620, 841630, 841690, 841780, 841790, 841810, 841821, 841830, 841840, 841861, 841869, 841919, 841939, 841940, 841950, 841960, 841989, 841990, 842010, 842091, 842099, 842119, 842121, 842123, 842129, 842131, 842139, 842191, 842199, 842220, 842290, 842833, 842940, 846291, 846596, 846599, 846694, 847130, 847160, 847170, 847410, 847420847431, 847432, 847439, 847480, 847490, 847710, 847720, 847730, 847740, 847751, 847759, 847780, 847790, 847920, 847982, 847989, 847990848110, 848120, 848130, 848140, 848180, 848190, 848210, 848220, 848230, 848240, 848250, 848280, 848291, 848299, 848340, 848360, 850161, 850162, 850163, 850164, 850231, 850239, 850300, 850410, 850421, 850422, 850423, 850431, 850432, 850433, 850434850440, 850450, 850490, 850511, 850519, 850520, 850530, , 850590, 850610, 850630, 850640, 850650, 850660, 850680, 850690, 850720, 850740, 850780, 850790, 850980, 851140, 851150, 851180, 851190, 851410, 851420, 851430, 851440, 851490, 851629, 851711, 851721, 851730, 851750, 851840, 852090, 852190, 852210, 852390, 852540, 852691, 852812, 852821, 852830, 853661, 853710, 853949, 854140, 854389, 854390, 870210, 870290870321, , 870322, 870323, 870324, 870331, 870332, 870333, 870390, 870410, 870421, 870422, 870423, 870431, 870432, 870490, 870510, 870520, 870530, 870540, 870590, 871110, 871120, 871130, 871140, 871150, 890790, 900190, 900290, 901510, 901520, 901530, 901540, 901580, 901590, 902410902480, 902490, 902511, 902519, 902580, 902590, 902610, 902620, 902680, 902690, 902710, 902720, 902730, 902740, 902750, 902780, 902790, 902810, 902820, 902830, 902890, 903010, 903020, 903031, 903039, 903040903082, 903083, 903089, 903090, 903110, 903120, 903130, 903140, 903149, 903180, 903190, 903210, 903220, 903281, 903289, 903290, 903300, 940510, 940520, 940540, 950720

Table 8: Correlation between Various Comparative Advantage Indices.

	Bahamas	Barbados	Belize	Cuba	Dominica	Dominican Republic	Guyana	Jamaica	St Vincent	Trinidad and Tobago
(REA,RTA)	0.866	0.845	n.a.	0.969	0.886	0.953	0.890	0.944	0.906	0.916
(REA,lnREA)	0.729	0.794	n.a.	0.969	n.a.	0.931	0.885	0.880	0.897	0.864
(REA,RC)	0.682	0.725	n.a.	0.961	n.a.	0.864	0.875	0.804	0.826	0.851
(RTA,lnREA)	0.842	0.907	n.a.	1.000	n.a.	0.945	0.962	0.916	0.953	0.942
(RTA,RC)	0.799	0.875	n.a.	0.992	n.a.	0.914	0.969	0.860	0.862	0.907
(lnREA,RC)	0.816	0.890	n.a.	0.992	n.a.	0.907	0.962	0.863	0.853	0.964

In terms of the areas of comparative advantage at the regional level, Figure 2 attempts to summarise the analysis done for each country into a single diagram. For each commodity, the number of countries that had a comparative advantage was plotted and provided in the diagram. The main areas that the region had similarities in terms of comparative advantage include air or vacuum pumps, air or other gas compressors and fans, ventilation or recycling hoods incorporating a fan and pumps for liquids. These were the only commodity categories where more than 7 countries had a revealed comparative advantage (the Bahamas, Barbados, Cuba, Dominica, Guyana, Jamaica, St. Vincent and Trinidad and Tobago). Other areas of some similarity in terms of comparative advantage include input or output automatic data processing machines, tamping machines and road rollers, and wind powered electricity generating sets and rotary converters. The above areas could be harnessed and expanded via the use of regional production clusters in order to leverage any potential benefits from liberalisation of the trade in green goods.

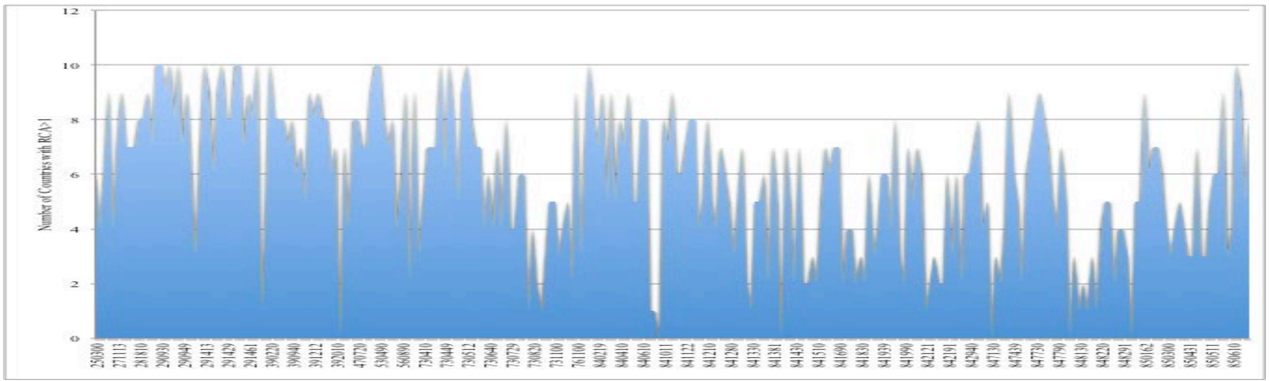

Figure 2: Similarity in Potential Green Export Commodity Categories for Selected Caribbean Countries.
Source: Authors' calculations.

The utility of developing regional clusters is particularly relevant given that any given Caribbean country would be unlikely to benefit from economies of scale in production. However, the region is quite heterogeneous in terms of the areas of comparative advantage. Table 2 provides an estimate of Kendall's rank correlation statistic (tau-a) in order to assess the association between the comparative advantage indices. Indeed, none of the bivariate tests of association exceed 0.5. This relatively high degree of heterogeneity in relation to the comparative advantages could make integration somewhat difficult, as production structures may not similar.

Table 9: Correlation between Revealed Comparative Advantage Indices for the Caribbean.

	Bahamas	*Barbados*	*Belize*	*Cuba*	*Dominica*	*Dominican Republic*	*Guyana*	*Jamaica*	*St. Vincent*	*Trinidad and Tobago*
Bahamas	*1.000*									
Barbados	*0.265*	*1.000*								
Belize	*0.079*	*0.280*	*1.000*							
Cuba	*0.361*	*0.189*	*-0.118*	*1.000*						
Dominica	*0.193*	*0.462*	*0.403*	*0.371*	*1.000*					
Dominican Republic	*0.003*	*-0.151*	*0.096*	*-0.156*	*-0.196*	*1.000*				
Guyana	*0.295*	*0.057*	*0.303*	*0.282*	*0.336*	*-0.195*	*1.000*			
Jamaica	*0.451*	*0.205*	*0.193*	*0.426*	*0.392*	*0.107*	*0.297*	*1.000*		
St. Vincent	*0.439*	*0.398*	*0.264*	*0.189*	*0.256*	*0.049*	*0.097*	*0.569*	*1.000*	
Trinidad and Tobago	*0.026*	*-0.008*	*-0.054*	*0.302*	*0.059*	*-0.044*	*0.026*	*0.190*	*-0.177*	*1.000*

Green exports provide opportunities for diversifying exports in the region as well as an adaptation mechanism to climate change. Indeed the Caribbean Specific Millennium Development Goals (CSMDGs) has a stated objective of integrating the principles of sustainable development into country policies and programmes. It was expected that this would be achieved via increases in resource efficiency, reduced carbon dioxide emissions and the proportion of the population using solid fuels by type of tenure. A green export push by the region would therefore be consistent with the CSMDGs and therefore the achievement of an improved standard of living for the peoples of the region.

The pursuit of a more resource efficient production structure would also reduce the vulnerability of the region to exogenous shocks due to large and unexpected changes in oil prices. Most countries in the Caribbean are highly dependent on imported energy (World Bank, 2010) and are therefore highly susceptible to large energy price shocks (Moore A. , 2011). A number of green export goods identified in the previous section were in the area of renewable energies (particularly for Barbados which has a fairly developed solar water heating industry). The greater diversification of the production into to these areas could not only generate benefits in terms of export possibilities but could further stimulate the greater utilisation of renewables in the energy mix.

To support the growth of green exports in the region, creating an enabling environment will be key. While one obvious to support these industries would be through tax breaks and other incentives, this is unlikely to be sustainable due to the fiscal constraints of the region. Green exporters in the region are likely to need support in relation to meeting standards, product promotion, research and development and ensuring that there is an adequate supply of trained individuals to support the industry. In most countries, as well as at the regional level, there exist institutional structures to support exporters that could be adapted to focus on green export opportunities. Leveraging the use of existing institutions would provide a low-cost, but high-impact technique for supporting the growth of a vibrant green export industry in the region.

Given the small basket of goods and services for which the region may have a revealed comparative advantage, combined with the constraints on the supply-side discussed above, imply that a multilateral approach to the reduction or elimination of tariff and non-tariff barriers to trade in environmental goods should consider the use of special and differential treatment for small states in the region. Such negotiations such also consider issues in relation to market access and subsidies. In many larger countries, green industries are highly subsidised. It is unlikely that small states would be able to match this level of subsidisation. The liberalisation of trade in environmental goods could therefore place small states at a competitive disadvantage.

One potential means to overcome these potential disadvantages due to size is to consider the development of green export industrial clusters. In many countries, such clusters have arisen without any systematic support at either the regional or national level. Leveraging these existing clusters and also supporting the growth of new clusters could allow the region to benefit from potential economies of scale (larger production plant) and scope (similarity of production techniques).

Conclusions

One of the main objectives of this paper was to consider the green export opportunities for the region. Using the proposed WTO universe of green goods, the study calculated revealed comparative advantage indices for 10 Caribbean countries over the period 2006 to 2009. The results suggest that for most countries, comparative advantages are likely to exist for less than 10 percent of the 510 goods on the WTO's provided universe of green goods. While this dissimilarity could limit the potential for regional integration, an alternative approach would be to consider the development of regional green export clusters. Such a strategy would need to be supported by an investment in building the enabling environment for green goods.

It is expected that future research in the area would explore the feasibility of the recommendations provided above. Future researchers in the area might also want to consider whether or not a green growth strategy does support sustainable development in small island states as well as measure the influence on environmental protection, carbon emissions and social equitability of environmental rights. In countries where green trade at its lowest (e.g. Haiti and Suriname), a greater push towards effective incentives for green investment, is required.

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METHODOLOGICAL AND THEORETICAL PERSPECTIVES TO CLIMATE CHANGE AND FUTURES STUDIES

Assessing Sustainability of Economic Growth with "Sustainability Window"

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This paper presents the concept of sustainability window, a novel quantitative method for assessment of economic expansion from both environmental and social sustainability perspectives. It can be used as an alternative or complementary assessment method for indicator sets evaluating multi-dimensional sustainability. It allows for definition of lower and upper boundaries of economic growth in respect to socio-economic sustainability and environmental sustainability. The sustainability window concept is used in a global study of 58 national economies in the period 1992–2009.

Purpose of the paper

This paper presents a new quantitative way of assessing sustainability of economic development and growth. The method allows for defining lower and upper boundaries of sustainability for economic growth that we call *sustainability window*. Our operationalization of sustainability of economic growth considers both socio-economic development and environmental impact. The concept is illustrated by presenting the sustainability windows of 58 economies for the time period 1992–2009 using gross domestic product, share of non-poor population of the total population and CO_2 emissions as indicator variables in the analysis.

Sustainability Measurement

Definition and measurement of sustainability and sustainable development remain as important challenges for research and policy-making. Numerous frameworks for its measurement have been created by scientists, NGOs and states. The main approaches for sustainability measurement are extended national accounts, bio-physical accounts, weighted indices, eco-efficiency and dematerialization approaches and indicator sets (Hezri and Dovers 2006). Sustainability is nowadays often thought to consist of three pillars: in addition to the environmental aspect, economic and social dimensions are considered. A debated question is whether sustainability evaluation should produce one aggregated indicator that unambiguously tells the level of sustainability (however it is defined and operationalized) and its change over time or retain some level of disaggregation to allow for making observations of the changes in the components of sustainability. The de-linked nature of the commonly understood dimensions of sustainability is problematic from the point of view of using a single aggregated indicator. However, an aggregated, generic sustainability index has great appeal for policy makers by being simple and unambiguous in terms of interpretation.

While easily interpretable, the problems in such generic indicators are that even while the dimensions that comprise sustainability could be operationalized reasonably well by simpler indicators, the dimensions are often incommensurable and large variation can exist in the preferences how the different dimensions should ultimately be weighted in assessing general sustainability. Sustainability assessment always includes a lot of normative judgment on what sustainability is and this judgment is reflected by what is assessed and what is not (Zeijl-Rozema, Ferraguto, and Caratti 2011). Inclusion of all relevant dimensions of sustainability is a central challenge for multi-dimensional sustainability evaluation.

The measurement of environmental dimension has perhaps been the most successful area of sustainability measurement. Well-known frameworks quantifying some aspect of environmental sustainability include the ecological footprint (Kitzes et al. 2007) measuring the share of bio-productive land and sea that is in human use, and material flow accounting (MFA) that focuses on the environmental performance of human activities measured by the amount of materials used (Schmidt-Bleek 1995). These indicators tend to be limited in the impacts they focus on and their capability to take into account the large variety of different environmental impacts. Examples of attempts to calculate monetary estimates of environmental costs and benefits of human activity include "Green GDP" frameworks such as the Genuine Progress Indicator (GPI) (Cobb, Halstead, and Rowe 1995). These indicators attempt to provide commensurability between different dimensions of sustainability by integrating them in monetary terms. The social dimension of sustainable development, on the other hand, is highlighted in indicators such as Human Development Index (HDI) or Human Sustainable Development Index (HSDI) which have been developed to reflect the level of development more comprehensively than the GNP per capita alone could reveal. A special feature of HDI is that it has a maximum value (1.00) making comparison of annual values problematic and decreases the indicators utility in recognizing change over time. An important advance in sustainability measurement would be to find ways to combine the different dimensions of sustainability and to evaluate them on a more commensurable basis. The *sustainability window* offers one possible way to evaluate the quality of the economic expansion, integrating the environmental and social sustainability perspectives.

Sustainability Window

Sustainability Window is a tool for assessing the sustainability of economic development, taking the environmental impact or the "cost" of the economic growth and the socio-economic impact or the "gain" of the economic growth into account. The sustainability window idea is derived from the Advanced Sustainability Analysis (ASA) framework presented by Kaivo-oja, Luukkanen and Malaska (2001), which has been used for sustainability evaluation (see Vehmas, Luukkanen, and Kaivo-oja 2007). The three concepts used by sustainability window (environmental impact, socio-economic impact and economic development) have to be operationalized by selecting an indicator to represent the change in these dimensions. Indicators that have a logical or practical upper limit (such as rankings and shares) can be problematic when used in the sustainability window framework. They can be used, however, with some caution.

One possibility for the choice of the indicators for sustainability window analysis and also the one that we use in determining the sustainability window for national economies in chapter of this paper is using Gross Domestic Product as a measure of economic development (the *econ* indicator), CO_2 as the measure of environmental impact (the *env* indicator) and the absolute amount of non-poor people as the measure of socio-economic impact (the *well* indicator). This operationalization is suitable only for developing economies that have significant amounts of people living under the 2.00$/day threshold. To examine developed countries, the framework could be amended to use some higher threshold of poverty.

Figure 1 illustrates how the bounds of the sustainability window are defined as well as the underlying reasoning behind the sustainability window concept. The development of CO_2 emissions and the number of non-poor people in China is indicated as a function of GDP. The starting year of the time series is 1990 and the indexed time series continue up to year 2009. The X-axis measures the relative change of GDP during the time period. The Y-axis measures the relative change of both CO_2 emissions and the amount of non-poor people.

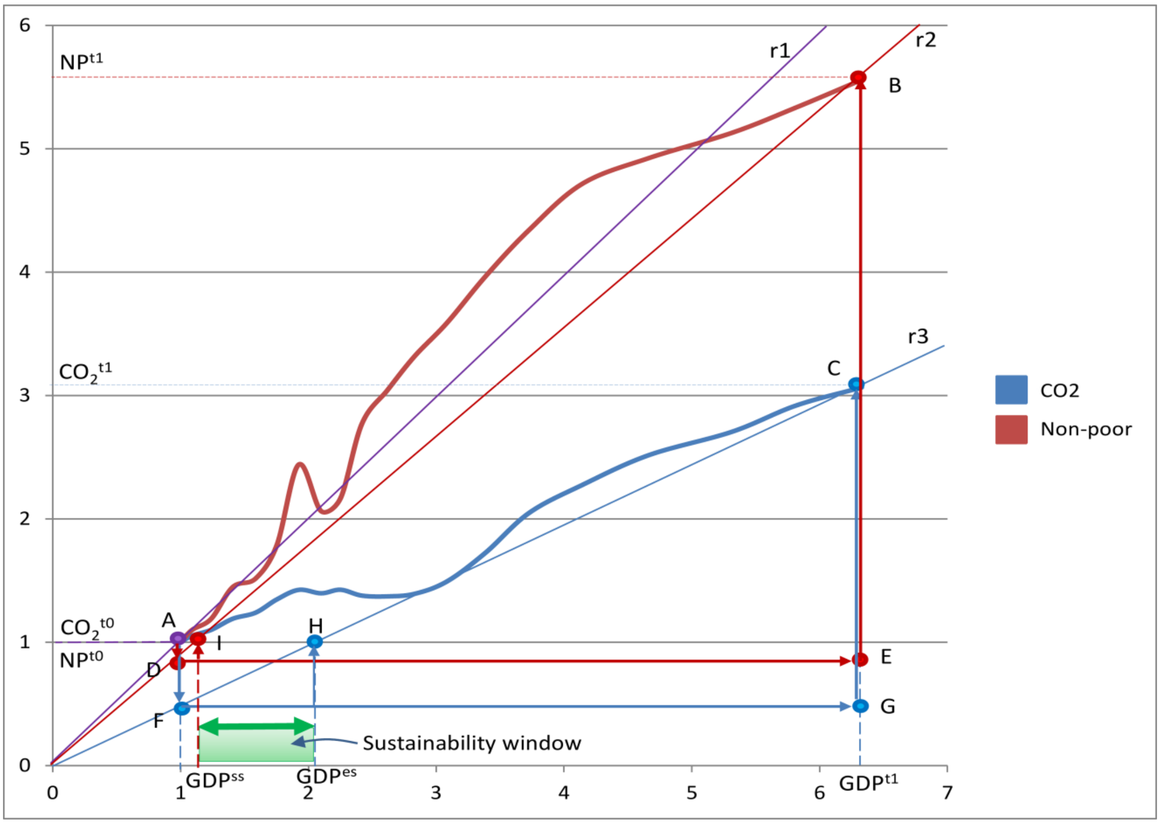

Figure 5. Changes in CO_2 emissions and number of non-poor people as a function of GDP in China in the period 1990–2009.

In the base year, 1990, the CO_2 emissions are CO_2t0, the number of non-poor people is NP_{t0} and gross domestic product is GDP_{t0}. The starting point for all indexed time series in figure 1 is point A. In the comparison year, 2009, the CO_2 emissions are CO_2t1, the number of non-poor people is NP_{t1} and gross domestic product is GDP_{t1}. GDP in 2009 is about 6.3 times the GDP of 1990. Points B,C,E and G are on the line perpendicular to X-axis and crossing it at GDP_{t1}. Point B indicates the number of non-poor people in 2009; Point C indicates the level of CO_2 emissions in 2009.

The ray *r1* represents characteristics of the socio-techno-economic production system of China in the base year, 1990. If the Chinese socio-techno-economic system would not have changed, the system's outputs would have developed along this ray: The CO_2 emissions and the amount of non-poor people would change accordingly. However, the system has changed so that the rays *r2* and *r3* describe the characteristics of the new socio-techno-economic production system in year 2009. In the changed system, GDP growth results in different production of non-poverty and CO_2. In order the development to be socially sustainable (sustainability understood in relation to poverty) the number of poor people should decrease, in other words the amount of non-poor people should increase. With the shift from ray *r1* to *r2* in the "non-poor productivity" of GDP the GDP should now grow at least to the level of GDP_{ss} (or shift to point I in the diagram) in order not to decrease the number of non-poor people. This indicates the minimum socially sustainable level of growth for GDP.

The shift from production ray *r1* to *r3* represents a decrease in CO_2 productivity of GDP, or an efficiency improvement, in the system. The maximum environmentally sustainable level of economic growth is GDP_{es}, at point H, where emissions do not grow compared to the starting point. The minimum socially sustainable level of growth for GDP (GDP_{ss}) and the maximum environmentally sustainable level of growth for GDP (GDP_{es}) define the lower and upper boundaries for the "sustainability window". When measured with these indicators, the level of economic growth should be within these boundaries in order to be at the sustainable level from both socio-economic and environmental perspective.

It is noteworthy that the lower bound of the sustainability window can be higher than the high bound of the sustainability window. This means that there is no sustainability window available. This is the case when the relative change in the *env* indicator exceeds the relative change of the *well* indicator. When the relative change of the well indicator is greater than the relative change of the *env* indicator, a sustainability window will be available and its size will grow along with the difference of well and *env* indicators as well as the relative change of the *econ* indicator. Having a sustainability window available should be positive with any reasonably selected indicators for *well* and *env* dimensions.

In order to *make* a sustainability window available or increase its size, the socio-techno-economic system should be changed in respect to its non-poverty productivity and CO_2 productivity. If the slope of ray *r2* representing the non-poverty productivity of the socio-techno-economic system is increased the sustainability window expands towards smaller economic growth. This means that the economic activity does not need to increase as much or that the growth in activity can even be negative if the increase in the system's productivity as measured by the *well* indicator is sufficiently great. Conversely, if the slope of ray *r3* representing the CO_2 productivity of the socio-techno-economic system is decreased the sustainability window expands towards greater economic growth. This means that the economic activity can increase more as the system produces less environmental harm measured by the *env* indicator at the same level of economic activity.

$$SW_{low_{t0-t1}} = \frac{\frac{econ_{t1}}{econ_{t0}}}{\frac{well_{t1}}{well_{t0}}} (1)$$

$$SW_{high_{t0-t1}} = \frac{\frac{econ_{t1}}{econ_{t0}}}{\frac{env_{t1}}{env_{t0}}} (2)$$

The calculation of the lower and upper bounds of sustainability window for the time period t0–t1 is presented in Equations 1 and 2. The *well* variable in the equation represents the socio-economic impact and in must be selected so that an increase in this indicator is interpreted as positive development in the socio-economic dimension of sustainability. In the China example of this section the indicator for this impact is the amount of non-poor people in the economy. In the country comparisons, the share of non-poor people in the population is the indicator for socio-economic impact. The *env* variable represents the environmental impact that must be selected so that an increase in it is interpreted as negative development in the environmental dimension of sustainability. In the China example and in the country comparisons the indicator for this impact is the level of CO_2 emissions from fuel combustion. The *econ* variable represents the level of economic activity. The indicator for this in the China example and in the country comparisons is gross domestic product.

The subscript t0 for variables *well*, *env* and *econ* represents the beginning of the time period for which the sustainability window is calculated. Subscript t1 represents the end of the time period. As statistical data for indicators suitable for representing the dimensions of sustainability in the framework is usually provided at best in one-year intervals, t0 and t1 will be years.

Economic development in different national economies evaluated with Sustainability Window

Source of data for all variables used in the calculation of sustainability window is the World Bank's World Development Indicator Database (World Bank 2012). Datasets for total population, CO_2 emissions, GDP at purchasing power parity in constant 2005 US$ and the percentage of population living on less than $2.00 a day at 2005 international prices have been used. As the non-poor population is used as the well indicator in our sustainability window calculation, the effect of population growth must be taken into account. As population grows, the absolute amount of non-poor people can grow even if the share of poor people in the total population grows. For this reason, the absolute amount of non-poor people would be a flawed indicator for social well-being. We use the relative share of non-poor people as the well indicator.

CO_2 emission level as an indicator for environmental impact in comparisons between countries can be seen as problematic for the least developed countries. The least developed countries usually have a very low per capita CO_2 emission level, and any development will likely grow the emissions.For this reason, in the country comparisons of this study, the increase in CO_2 emissions is calculated only if they grow beyond a set "sustainable" level, which is set at 1.8 tons per capita. If a country's emission level is below 1.8 tons per capita at *t0* and above 1.8 tons per capita at *t1*, the sustainability window is calculated so that the growth in emissions is the total emission level in *t1* - population at *t0* ×1.8 tons. This makes it possible for countries with low per capita CO_2 emissions to remain inside their sustainability windows even when the absolute level of emissions grows.

While data coverage for GDP and CO_2 emissions is very good, the availability of data for poverty is not as good and is available for most countries only at intervals. The calculation of the sustainability window requires data for all three indicators for both start and end years. Instead of selecting a single year for both t0 and t1, we have used time spans from which the values for the different indicators have been averaged. If only one data point for an indicator was available within the data span, that data point was used as the value t0 or t1 for the indicator. If there was more than one data point available within the time span, the available data points were averaged and the average was used as the t0 or t1 value for the indicator. In the calculation of the sustainability windows, we have used the year span 1990–1992 as t0 and the year span 2007–2011 as t1. These year spans have been selected on the basis of optimal data availability, so that the number of countries with at least one data point for each indicator for both year spans is maximized. The selected year spans provide data for calculating the sustainability window for 58 countries.

Table 10. Sustainability Windows for 58 countries.

Country name	Low bound	High bound	SW exists	Actual growth	Growth in SW
Argentina	78.1 %	19.7 %		78.5 %	
Bangladesh	-29.0 %	137.7 %	X	137.7 %	X
Belarus	88.6 %	134.2 %	X	88.5 %	
Bolivia	94.8 %	83.7 %		83.7 %	
Brazil	31.2 %	23.2 %		65.0 %	
Bulgaria	50.2 %	90.9 %	X	49.9 %	
Burkina Faso	25.9 %	143.8 %	X	143.8 %	X
Cambodia	74.3 %	221.7 %	X	221.7 %	X
Central African Republic	-41.6 %	28.8 %	X	28.8 %	X
Chile	98.6 %	10.3 %		116.4 %	
China	34.3 %	90.9 %	X	400.4 %	
Colombia	78.1 %	72.7 %		72.7 %	
Costa Rica	97.1 %	118.2 %	X	118.2 %	X
Cote d'Ivoire	41.4 %	34.3 %		34.3 %	
Dominican Republic	139.0 %	60.7 %		150.3 %	
Ecuador	42.7 %	7.7 %		68.7 %	
Egypt, Arab Rep.	83.4 %	9.1 %		114.4 %	
El Salvador	40.1 %	68.8 %	X	68.8 %	X
Guinea	-41.4 %	79.1 %	X	79.1 %	X
Honduras	26.6 %	85.9 %	X	85.9 %	X
Hungary	43.2 %	63.6 %	X	43.1 %	
India	72.1 %	194.7 %	X	194.7 %	X
Indonesia	-35.9 %	98.2 %	X	98.2 %	X
Jordan	111.5 %	30.1 %		143.8 %	
Kazakhstan	44.0 %	74.4 %	X	72.7 %	X
Kyrgyz Republic	12.7 %	64.7 %	X	23.0 %	X
Lao PDR	29.6 %	190.3 %	X	190.3 %	X
Latvia	68.6 %	180.2 %	X	68.1 %	
Lithuania	27.1 %	101.5 %	X	52.3 %	X
Madagascar	149.1 %	58.9 %		58.9 %	
Malaysia	123.2 %	-6.0 %		144.8 %	
Mali	-35.1 %	125.5 %	X	125.5 %	X
Mauritania	8.0 %	156.8 %	X	79.9 %	X
Mexico	38.5 %	10.5 %		54.3 %	
Moldova	-46.6 %	186.2 %	X	-17.7 %	X
Morocco	79.5 %	83.5 %	X	83.5 %	X
Niger	-39.4 %	72.9 %	X	72.9 %	X
Nigeria	161.8 %	107.3 %		107.3 %	

Pakistan	-41.1 %	98.4 %	X	98.4 %	X
Panama	95.3 %	52.4 %		134.6 %	
Paraguay	69.0 %	50.2 %		50.2 %	
Peru	85.9 %	121.0 %	X	121.0 %	X
Philippines	52.6 %	94.0 %	X	94.0 %	X
Poland	97.5 %	135.7 %	X	105.9 %	X
Romania	35.8 %	117.5 %	X	51.4 %	X
Russian Federation	18.7 %	51.7 %	X	29.2 %	X
Senegal	-18.3 %	85.8 %	X	85.8 %	X
Slovak Republic	88.8 %	121.5 %	X	88.5 %	
South Africa	43.1 %	21.3 %		66.9 %	
Sri Lanka	56.3 %	127.6 %	X	127.6 %	X
Tanzania	67.5 %	133.8 %	X	133.8 %	X
Thailand	40.9 %	-12.3 %		90.0 %	
Tunisia	80.2 %	31.9 %		113.1 %	
Turkey	78.5 %	2.2 %		89.1 %	
Uganda	0.9 %	213.0 %	X	213.0 %	X
Ukraine	-13.4 %	52.9 %	X	-13.5 %	
Uruguay	55.6 %	20.6 %		57.3 %	
Vietnam	-16.8 %	229.7 %	X	229.7 %	X

Table 1 shows the sustainability windows for 58 countries for which there was sufficient data available. The examination period is 1992–2009 with the yearly values averaged as explained above. 8 of these countries are in Sub-Saharan Africa, 12 in Asia, 11 in East Europe, 2 in North Africa and 4 in Latin America.

22 of these countries have no high bound for their sustainability windows as the per capita CO_2 emissions remained below 1.8 tons in the examination period. For these countries, the high bound of their sustainability window is effectively the same as their actual growth. 15 of the 37 countries that have a sustainability window for the period 1992–2009 have a "genuine" sustainability window, meaning that they also have an high bound for their economic expansion.

30 countries out of the 37 countries having a sustainability window had their economic growth within the bounds of their sustainability windows. 22 of these were developing countries with CO_2 emissions below 1.8 tons per capita, and so having no high bound for their sustainability windows. 7 countries in the group having a genuine sustainability window did stay inside their sustainability window bounds in the examination period. These countries were Mauritania, Kazakhstan, Kyrgyz Republic, Lithuania, Moldova, Poland, Romania and Russia. Most of the countries that do have their per capita CO_2 emission level above 1.8 and are within their sustainability windows have experienced some population de-growth in the period. The East European countries have also undergone thorough restructuring of their industrial systems, resulting in major reductions in CO_2 emissions. On the other hand, the African countries have experienced great population growth: e.g. the population growth of Mauritania is 60%. In African countries, the relative growth of the non-poor population is in many cases multiple times the relative growth of total population. In the East European countries within their sustainability windows, the

decline in non-poor population is smaller than the decline in total population. Growth in the 37 countries within their sustainability windows ranges from -17% (Moldova) to 229.7% (Vietnam).

Discussion

The presented Sustainability Window approach has its merits in comparison to other frameworks for analysing sustainability. The economic, social and environmental dimensions of sustainability are integrated into the same analytical framework. The dimensions can be operationalized differently by using different indicators and the sustainability window idea can be used to analyse several sustainability related phenomena. The method is also conceptually simple and very easy to use. The sustainability window can also be calculated with several indicators within the same exercise, yielding several sustainability windows. The overlap of these windows can be thought as the combined sustainability window of all the used indicators. This way the framework can be made to include all the aspects considered relevant, although adding new indicators will at best keep the sustainability window at the same size and often narrow it down more.

The selection of indicators used in the example case of this article can naturally also be problematized, as every selection of indicators highlights some aspect of reality and disregards others. The indicator selection used in this study is not trumpeted by the authors to be the best. It is a reasonable selection of indicators to illustrate the sustainability window idea, and the sustainability window calculation that we present has to be seen only as an illustration of the method. It can be improved further by a more careful selection of indicators and the possible boundary conditions and other considerations related to these indicators.

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Solar Resource Modelling for Tropical Regions Using the Markov Transition Probability Matrix Method

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As measured solar insolation data is not available for all locations; modelling the resource is important in the planning of energy systems that include the use of PV panels. Extraterrestrial insolation is predictable and can be calculated for any location. Sunshine duration and intensity vary depending on the season, month and latitude of the particular location. Therefore the insolation throughout the day can be predicted using parameters that represent the month, latitude and additional location information. However, due to the presence of atmospheric variations, air mass changes and clouds, the insolation is rendered stochastic(Duffie & Beckman, 2006). These effects are defined by the clearness index. The clearness index is the ratio of the measured solar insolation to the extraterrestrial insolation in each time step. The Markov transition probability matrix (MTPM) method for modelling the clearness index was used to develop the half hourly clearness index time series model. The clearness index time series was then applied to the calculated half hourly extraterrestrial insolation time series to determine the beam, diffuse and reflected insolation on a tilted solar collector for each half hour. The three insolation types were summed to find the solar insolation for each time step for one year.

Introduction and Background

Half hourly solar insolation data was required as an input to the simulation of a small rural remote PV-wind-diesel energy system. As obtaining measured solar insolation data for the location of the energy system was difficult possible and the available data was incomplete, the aim of this work is to develop a suitable half hourly solar insolation model that is representative of the resource at the location of the proposed rural remote PV-wind-diesel hybrid energy system. The Markov transition probability matrix (MTPM) method for modelling the solar insolation resource was applied. The MTPM method calculates the probability of an event occurring in the next time step based on the event taking place at the present time (Grinstead and Snell, 2006).

The use of the Markov transition probability matrices has been shown to be suitable for the modelling of the clearness index (***Kt***)[55] (Amato et al, 1986, 179–194; Nguyen et al, 1996, 1274–1278; Morf 1998, 101–112; Kamal et al, 1999, 565–572; Aguiar et al, 1988, 269–279; and Ehnberg et al, 2005, 157–162). The Markov method can be used to simulate daily solar insolation (Amato et al, 1986, 179–194; Aguiar et al, 1988, 269–279; and Nguyen et al, 1274–1278) while Kamal et al and Ehnberg et al applied the method to modelling hourly and six minute models respectively(Kamal et al, 1999, 565–572 and Ehnberg et al, 2005, 157–162). Kamal developed four MTPMs, one for each season, to produce the hourly average radiation model (Kamal et al, 1999, 565–572). Analyses of the generated time series showed similar statistical properties and probability distributions to the measured data. Levels of cloud cover have been used to create the Markov transition probability matrix and clearness index time series. The modelled time series was used with the sun position for the location and time of day to create hourly and

[55] $\overline{\boldsymbol{Kt}}$ represents the monthly clearness index, ***Kt*** the daily clearness index and ***kt*** the hourly clearness index. As hourly clearness indices are not used in this work, ***kt*** was to represent the half hourly clearness index.

daily insolation models (Morf, 1998, 101–112; Kamal et al, 1999, 565–572; Aguiar et al, 1988, 269–279; and Ehnberg et al, 2005, 157–162).

Validation of clearness index time series models includes comparisons of the mean, standard deviation and the autocorrelation coefficient, at lag 1, of the models (Aguiar et al, 1988, 269–279; and Ehnberg et al, 2005, 157–162 and Knight et al, 1991, 109–120). Autocorrelation of the clearness index measures the dependency of the current clearness index on previous values. The lag 1 autocorrelation is the dependence at a onetime step separation. Knight *et al* also compared the cumulative distribution functions (cdf) of the measured and modelled daily clearness indices. Saunier et al argued that the cumulative distribution functions of solar insolation as put forward by Lui and Jordan were not valid for tropical regions as these were developed from North American data. Lui and Jordan had developed a set of cumulative distribution functions that represented the distribution of daily global radiation over a month and were almost independent of the location and month of measurement (Lui & Jordan 1960, 1–19). Vijayakumar *et al* investigated the effects of using hourly insolation data in the modelling of solar energy systems (Vijayakumar et al, 2005, 495–504). These effects were compared to the performance of the system using shorter term data. The distributions of daily and hourly insolation data were shown not to represent distributions based on the 3 minute time step used in the data assessment.

Due to the argument put forward by Vijayakumar and, based on the findings of Saunier, the half hourly solar insolation model was developed using monthly MTPMs calculated from the measured solar insolation in the tropical region.

Solar insolation modelling program

The solar radiation data used in the development of the solar insolation model was measured at latitude 18.5^{o}N, longitude -77^{o}W in Jamaica and was recorded in 2002 by the Climate Branch of the Meteorological Service of Jamaica. All data was assumed to have been measured using a pyranometer mounted on an unshaded horizontal plane.

The measured solar insolation data was used with the calculated extraterrestrial insolation to determine the half hourly clearness indices of the measure data. The Markov transition probability matrix method was then used to develop half hourly clearness index time series models. The validity of the models was assessed by comparing the means, standard deviations, frequency distributions and the autocorrelation coefficients of the clearness index model to the clearness index time series of the measured solar insolation. After validation, the solar insolation model on a horizontal plane was calculated from the clearness index time series. This was then converted to the expected resource on a tilted collector. Assumptions made in the calculations were: (1) The solar panels were fixed, (2)Solar panels were not shaded, (3) Solar panels faced south. The program modules were implemented using the MATLAB technical computing tool. The major modules for the development of the solar radiation model are shown in Figure 1.

Input measured solar data

The measured solar radiation was read into the program from a text file. The dates of the missing data from the measured solar radiation data were noted and used to eliminate the corresponding dates from the calculated extraterrestrial radiation data. The monthly average sunset and sunrise times of the measured insolation data were recorded and used to set that of the solar insolation time series model.

Clearness index

Clearness index $\boldsymbol{kt}$ is the ratio of measured insolation to the extraterrestrial insolation on a horizontal plane and is a measure of the clearness of the sky. A value of $\boldsymbol{kt}$ closer to 0 indicates a decrease in sky clearness, more clouds and impurities are in the sky. A value of $\boldsymbol{kt}$ closer to 1 indicates an increase in sky clearness, implying that there are fewer clouds or impurities in the sky (Masters, 2004). Equation 1 was used to calculate the half hourly clearness index.

$$kt = \frac{I}{I_o} \quad (1)$$

$\boldsymbol{I}$ and $\boldsymbol{I_o}$ are the measured half hourly insolation and the extraterrestrial insolation for the particular hour.

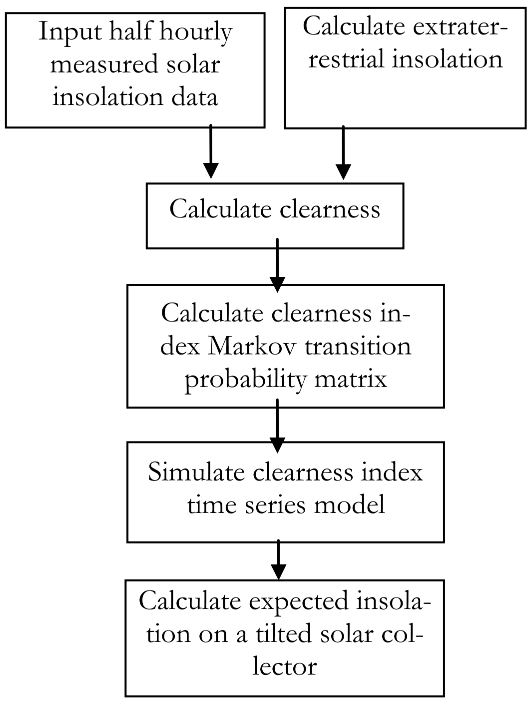


Figure 1. Solar insolation program modules.

The total extra-terrestrial insolation (Wh/m^2) for each half hour is given as: (Duffie & Beckman, 1991).
Where:

$$I_0 = \frac{1800}{\pi} * SC\left[1 + 0.033\cos\left(\frac{360n}{365}\right)\right] * (\cos L \cos \delta \sin H + H \sin L \sin \delta) \quad (2)$$

Where:

$\boldsymbol{I_O}$ is the extra-terrestrial insolation (Wh/m^2),

$\boldsymbol{SC}$ is the solar constant (kW/m^2), 1.377kW/m^2 (Masters, 2004)

$\boldsymbol{n}$ is the day number,

$\boldsymbol{L}$ is the latitude of the site,

$\boldsymbol{\delta}$ is the solar declination,

$$\delta = 23.45 \sin\left(\frac{360}{365} * (n - 81)\right) \quad (3)$$

H is the hour angle for the half hour, (Modified for half hour time step) (Masters, 2004)

$$H = 7.5 * (12 - h) \quad (4)$$

Where ***h*** is the time of day in 24hr time format.

Clearness index Markov transition probability matrix (MTPM)

The clearness index MTPMs for each month was calculated to ensure that seasonal variations were not eliminated. The state size of the clearness index MTPMs is one tenth of the difference between the maximum and minimum clearness index for the month as shown in Equation 5.

$$b = \frac{kt_{max} - kt_{min}}{10} \quad (5)$$

Where:

b is the state size

kt_{max} is the maximum clearness index

kt_{min} is the minimum clearness index

The maximum value ***S*** of each state is therefore:

$$S = kt_{min} + ib \quad (6)$$

Where: ***i*** = 1 to 10

The steps used to calculate the MTPM to create the model, were (Masters, 1999): The transition from each clearness index state to other states was counted for the entire data set using Equation 7.

$$K_{ij} = \sum_{j=1}^{k} T_{ij} \quad i = 1, 2, \quad k \quad (7)$$

Where: ***K*** is the number of times the clearness index transitioned from clearness index ***i*** to ***j*** for the full set of data. T_{ij} is a transition from clearness index state ***i*** to clearness index state ***j*** and is either *0* or *1*.

The next step was to count transitions from each clearness index as shown in Equation 8.

$$C_i = \sum_{i=1}^{k} T_i \quad (8)$$

Where: C_i is the total number of transitions from clearness index state ***i*** to all other clearness index states.

T_i is a transition from clearness index state ***i*** and is either *0* or *1*.

The transition probabilities of the MTPM were calculated using Equation 9.

$$P_{ij} = \frac{K_{ij}}{C_i} \quad (9)$$

Where: P_{ij} is the probability of transitioning from clearness index state ***i*** to clearness index state ***j***.

The Markov transition probability matrix for August is shown in Table 1. A 2x10 matrix (Table 2) was created to contain the mean clearness index and standard deviation of each state for each month. This information was used in calculating values of the clearness index time series model.

Clearness index time series model

The Markov transition probability matrices were used to generate a sequence of state transitions for each month. The Markov chain program (Zirbel, 2006) was repeated for all months with the sunset and sunrise times included in the input data. The values of the clearness indices, ***kt***, were then calculated using the means and standard deviations, (Table 2), of each of the generated states in the time series (Equation 10).

$$kt = \mu_S + \sigma_S R \quad (10)$$

Where: μ_S and σ_S are the mean and standard deviation of the measured data for each month and state ***S***, ***R*** is a random number between 0 and 1 used to include variations about the mean of the clearness index state. A wider range for ***R*** would give more variation but may also result in a change of clearness index state.

Table 1. August Markov transition probability matrix.

State.	1	2	3	4	5	6	7	8	9	10
1	0.726	0.097	0.113	0.033	0.016	0.016	0	0	0	0
2	0.171	0.229	0.257	0.146	0.171	0.029	0	0	0	0
3	0.113	0.170	0.245	0.17	0.132	0.113	0.038	0	0	0.019
4	0	0.026	0.256	0.128	0.333	0.128	0.128	0	0	0
5	0.019	0.02	0.038	0.115	0.269	0.211	0.173	0.077	0.019	0.058
6	0	0.052	0	0.103	0.128	0.128	0.333	0.154	0.077	0.026
7	0.032	0.032	0	0.032	0.095	0.127	0.206	0.302	0.111	0.063
8	0	0	0.092	0	0.062	0.062	0.138	0.262	0.23	0.154
9	0	0	0.036	0.071	0.024	0	0.06	0.155	0.405	0.25
10	0	0	0	0.007	0	0.007	0.046	0.046	0.158	0.737

Table 2. August state means and standard deviations.

	1	2	3	4	5	6	7	8	9	10
Mean	0.024	0.104	0.161	0.231	0.3	0.363	0.424	0.486	0.561	0.608
St.dev.	0.021	0.02	0.012	0.02	0.019	0.018	0.02	0.02	0.018	0.013

Material and Methods

The beam, diffuse and reflected solar insolation on a horizontal surface was calculated from the modelled data. These were then converted to the insolation that would fall on a tilted PV panel using relationship equations for converting insolation on a horizontal surface to that on a tilted surface by Masters (Masters, 2004) and Duffie and Beckman (Duffie & Beckman, 1991).

Results

The output of the program includes:

1. Markov transitional probability matrices for each month.
2. Mean clearness indices and standard deviations for each state for each month.
3. The clearness index time series model. The program was run multiple times and two random models were chosen for validation in order to determine the consistency of the results. There was no change or difference in the inputs to the program for either model.
4. Solar insolation model. The model was output to a MS Excel file.

Validation

Annual and monthly clearness index means

The annual mean and standard deviation of the clearness index time series models are similar to that of the measured data as shown in Table 3. The comparison of the means and standard deviations of the monthly clearness index models to the measured data is shown in Table 4. The means of the clearness index models show that the models are similar to that of the measured data with the annual mean of Model 1 differing from the annual measured mean by only -0.5%.

Table 3. Comparison of annual mean clearness indices.

Data	Annual mean	Annual standard deviation	Difference from measured annual mean (%)
Measured	0.3983	0.2007	-
Model 1	0.3964	0.2013	-0.5
Model 2	0.4086	0.2008	2.5

Table 4. Comparison of monthly means of clearness index time series models.

Month	Mean			Difference from measured data mean (%)	
	Measured data	Model 1	Model 2	Model 1	Model 2
January	0.3895	0.4319	0.4220	11	8.3
February	0.4158	0.4676	0.4745	12.5	14
March	0.4504	0.4761	0.4787	5.7	6.3
April	0.5001	0.4631	0.5296	-7.4	5.8
May	0.3445	0.3251	0.3624	-5.6	5.2
June	0.3942	0.4414	0.4465	12	13.3
July	0.4117	0.4318	0.4622	5	12.3
August	0.3793	0.4236	0.4007	11.7	5.6
September	0.3054	0.3267	0.3168	7	3.7
October	0.4056	0.2414	0.2606	-40	-35.7
November	0.4095	0.3724	0.3954	-9.1	-3.4
December	0.3758	0.3502	0.3481	-6.8	-7.4

Aguiar recommended that the monthly clearness index simulations should be repeated until the mean of the modelled time series is close to the average required for the model (in this case the annual mean) (Aguiar et al, 1988, 269–279). The annual means of both models are within ±5% of the annual clearness index mean of the measured solar insolation data, therefore no other models were required.

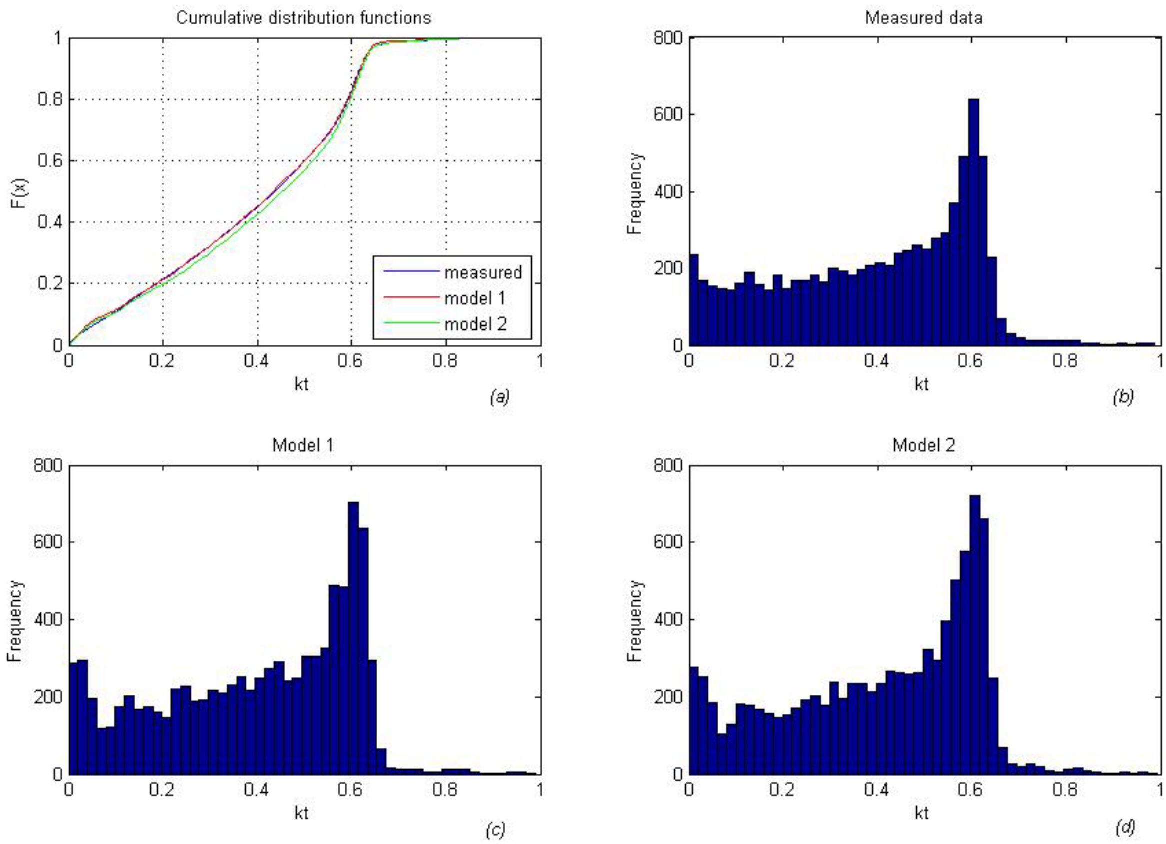
The comparison of the monthly means of the measured and modelled clearness indices show that the monthly means of the models are within ±15% of that of the measured data, with the exception of October where the difference is approximately 40%. The program recognised the wide variation in clearness indices in October thus affecting the models genereated. However, as both annual means are within ±5%, as stated previously, and as the validity of the models cannot be proven by these statistics alone; further assessment of the models was required.

Cumulative distribution function and histogram

The cumulative distribution functions of the measured and modeled time series were plotted and shown in Figure 5. All occurrences of $\boldsymbol{kt} = 0$ (representing night-time) were removed from the sets. Figure 5(a) shows the cumulative distribution function plots of the half hour clearness indices for the measured and the modeled data. Based on the plot, Model 1 appears similar to the measured data. Figure 5(b), 5(c) and 5(d) are the frequency histograms for the measured data and the models.

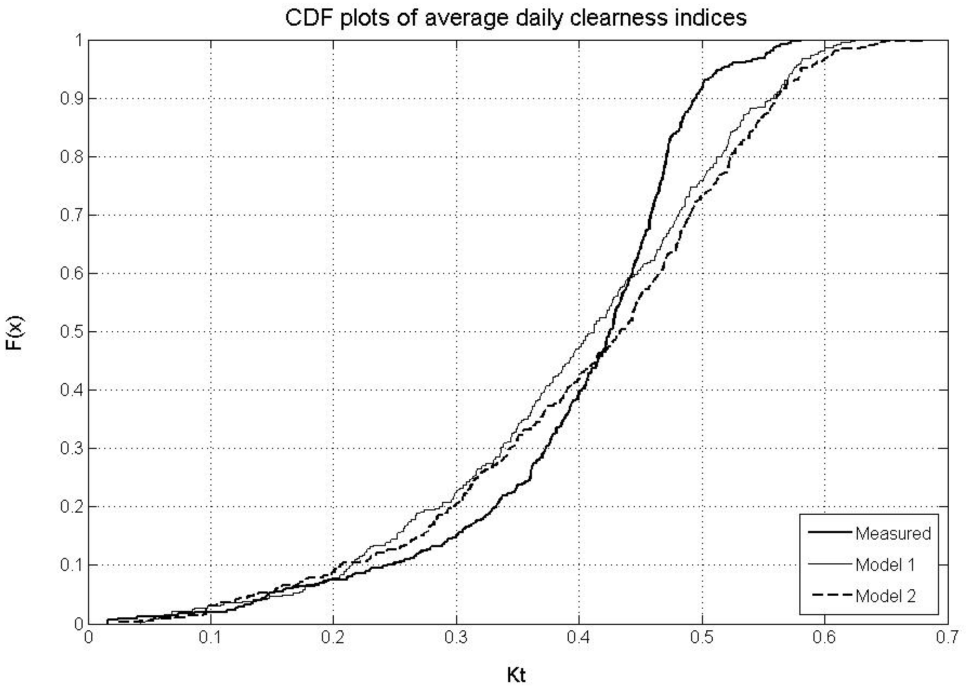
The daily average clearness indices for the measured and modeled data were calculated (night-time data removed). Figure 6 shows the cumulative distributions function plots of the daily average clearness indices.

Figure 5. CDF plots and histogram of half hourly clearness indices.



From a visual inspection of the cdf plots in Figures 5 and 6, the argument put forward by Vijayakumar that the daily distribution does not represent the distribution of shorter time step models, (half hourly model in this case) does seem to apply to these models (Vijayakumar et al, 2005, 495–504).

Figure 6. CDF plots of daily clearness indices.



Kolmogorov-Smirnov test

The Kolmogorov-Smirnov (K-S) test was used to determine the maximum difference between the cumulative distribution functions of the half hourly clearness index plots. The result of the K-S test would indicate if the hypothesis that the two continuous distributions had the same underlying distribution could be rejected (Marques de Sa, 2007).

If the maximum difference between the two distributions was greater than the critical value, the hypothesis that the underlying distributions were similar could be rejected. The critical value, KS_{crit}, was determined using Equation 11 (Masters, 1999; Zirbel, 2006; Marques de Sa, 2007, Gregory, 1963).

$$KS_{crit} = 1.36\sqrt{\frac{n_1 + n_2}{n_1 \times n_2}} \quad (11)$$

Where: $n1$ is the length of the clearness index time series obtained from measured insolation. $n2$ is the length of the modelled clearness index time series.

Given that the length n_1 of the measured clearness index time series (after removal of night time data) was 7933, and the length of the modelled clearness index time series n_2 was 9035, the critical value of the cumulative distribution functions of the clearness indices was:

$$KS_{crit} = 1.36\sqrt{\frac{7933 + 9035}{7933 \times 9035}}$$

$$=0.02093$$

The ***kstest2*** function in the MATLAB statistics toolbox was used at the 5% significance level to determine the maximum difference between the measured and modelled clearness indices. The results of the test are given in Table 5:

Table 5. Maximum difference between the half hourly cumulative distributions of the measured and modelled clearness indices.

Model	M
Model 1	0.0160
Model 2	0.0323

Based on this result, there is less than 5% chance that Model 1 and the measured data are not from the same distribution as the value of ***M*** is less than the critical value. However, Model 2 is not from the same distribution as the measured data.

The K-S test was applied to the daily average clearness indices with the following results (Table 6):

$$KS_{crit} = 1.36\sqrt{\frac{346+365}{346\times365}}$$

$$=0.10204$$

Table 6. Maximum difference between the daily cumulative distributions of the measured and modelled clearness indices.

Model	M
Model 1	0.1688
Model 2	0.2027

Both cumulative distribution functions of the average daily clearness indices models failed the K-S tests. This agrees with the findings in (Vijayakumar et al, 2005, 495–504) regarding the differences in the distributions of daily and hourly insolation models to models with shorter time steps. The results of the K-S tests were expected as the models are half hourly clearness index time series models.

Autocorrelation

The autocorrelation coefficient of the time series is a measure of the relationship between values of the series at different time steps (NIST/SEMATECH. NIST/SEMATECH). A coefficient value of -1 indicates anti correlation while 1 indicates perfect correlation. For a test of non-randomness, the first lag autocorrelation (lag 1) is of interest. The autocorrelation results of the measured data and the modelled clearness index time series for a lag of 1 are given in Table 7.

Table 7. Autocorrelation coefficient at lag 1 for measured and modelled half hourly clearness indices.

Model	Autocorrelation coefficient
Measured	0.9612
Model 1	0.9591
Model 2	0.9615

From these results, the level of correlation between the values of the modelled clearness index time series were similar to that of the clearness indices of the measured data.

Discussion and Conclusions

The aim of this work was to provide a suitable solar insolation model that is representative of the expected resource for use in the design of small rural PV-wind-diesel hybrid energy systems. The Markov transition probability matrix method for modelling the half hourly clearness index was applied. The expected solar insolation on a tilted collector was calculated using the clearness index time series model. Although the inputs were the same, validation tests on the models confirm that Model 1 is a better representation of the clearness index time series of the measured solar insolation. This is due to the random variables introduced in the generation of the clearness index time series models. The comparison of the clearness index time series means of Model 1 and Model 2 to the mean of the measured clearness index time series shows that the mean of Model 2 differed 450% more than the mean of Model 1.

Model validity was also checked using tests on the cumulative distributions. The K-S test was applied to both models. The difference between the cumulative distribution functions of Model 2 and measured clearness index time series show that both time series do not have similar underlying distributions. However, this was not so for Model 1 as the K-S test results indicate that there is a 95% chance that Model 1 and the measured clearness index time series have similar underlying distributions.

Although the autocorrelation coefficient (at lag 1) for Model 2 is closer to that of the measured clearness index time series than Model 1, both autocorrelation coefficients were 1% of that of the measured clearness index time series. Therefore, based on the results of the validation process, Model 1 was converted to the solar insolation time series model.

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The Social and Cultural Dimensions of Sustainable Development, Mitigation and Scenarios: Grasping the Opportunities for Human Development

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This paper discusses the social and cultural dimensions of sustainable development and mitigation as inputs to analysis and policy. A false match between consumption and wellbeing is driving intractable environmental pressures and requires more attention from the research and policy communities. Research into the links between human development, consumption and emissions is not well developed (Jackson, 2003; Jackson, 2005; SEPA, 2012). This paper seeks to explore the links between these related concepts and highlight opportunities to expand inquiry and policy-driven discourse on an issue that is paramount both for human wellbeing and mitigation. It seeks to focus more specifically on the relationships with energy and related carbon emissions as themes of prime policy significance globally. After the introduction, the paper is structured through a discussion of emissions driving forces in section 2, human development and sustainable development in section 3, social and cultural dimensions, and needs and consumption in sections 4 and 5. Sections 6 and 7 address wellbeing and transformation frameworks and a discussion and conclusion follows in the final section.

"Problems cannot be solved with the same mind-set that created them."

– Albert Einstein –

The driving forces of emissions

As many biophysical and social systems are complex in evolution and poorly understood (Nakicenovic *et al.*, 2000: 62) addressing climate change has driven an evolution in methods and discourse. van Asselt (2000) described "complex problems" as a tangled web of problems (multiproblem), the issues concerned transcend disciplines (multi-dimensional) and underlying processes interact at various scales (multi-scale). The approaches to inquiry of complex problems can be multidisciplinary, interdisciplinary and transdisciplinary, or additive, interactive and holistic (Choi and Pak, 2006) and single discipline approaches are generally no longer favoured. Systems theory has explicated key categories including simple systems, complicated systems, complex systems and chaotic systems, with social systems exhibiting properties in the latter categories. Futures research is a complexity science (Samet, 2011) within which the scenario method is useful in exploring non-linear relationships, uncertainty in evolution and qualitative driving forces that cannot be quantified.

Mitigation itself is a domain of human systems, human actions and development, and its relationship with energy and emissions must be understood in this context. Understanding of the driving forces of development, and indeed energy and carbon emissions, have been advanced considerably by global scenario studies (UNEP GEO, UN MEA, IPCC SRES[56]). The common prescription of driving forces is conceived around the Kaya iden-

[56] UNEP Global Environmental Outlook, UN Millenium Ecosystem Assessment and the IPCC Special Report on Emission Scenarios are important global scenario exercises.

tity[57] (Kaya, 1990), linking population, economy and technology and it was used as the basic organising principle for the IPCC SRES (Nakicenovic et *al*., 2000). While quantitative modelling of future states is necessary to understand the energy system and inform policy development, a number of limitations have been acknowledged. These include not only difficulties in the complexity of analysing economic and technological variables, inaccuracy, hidden biases and subjectivity (O´Neill, 2005; Önkal *et al*., 2013; O´ Mahony, 2014)[58] but problems in engaging with uncertainty and driving forces which may not be quantified; primarily social, cultural and governance[59]. Models also entail an inherent worldview which has implications for embedding a particular perspective on energy and economic functions such as consumption. This has important implications for the development path and can reinforce lock-in and hamper attempts at transformation (Borjeson *et al*., 2006: 726). Future transition paths are a major scientific challenge and hybrid integration of qualitative and quantitative inquiry is acknowledged as the way forward (Sathaye *et al*., 2007). The IPCC AR5 has prioritised holistic techniques that incorporate society and wellbeing (Fleurbaye *et al*., 2014:6). In contrast, literature on the environmental Kuznets curve (EKC) has hypothesised that an inverted U-shaped curve will eventually see emissions drop as income increases. However, problematic N-shaped curves are possible, evidence is mixed, the statistical basis is weak and other omitted variables such as inequality have proven significant (Galleoti *et al*., 2006). While the EKC may hold for some pollutants, there is little evidence that this simple predictable relationship can be determined for carbon emissions as energy consumption continues to grow with income (Stern, 2004). The benefit of a scenario approach in this context is the ability to represent uncertain dynamics and evolution in the scenarios. Defining a set linear relationship is therefore not necessary and alternative plausible relationships between emissions and income can be explored.

The scenarios literature has explicated a broad conception of scenario driving forces in the *´six sector approach´* (de Jouvenel, 1986; Kelly *et al*., 2004; O´ Mahony, 2014), including social, cultural and governance driving forces. This has been reflected in the wide conception of *national development paths* espoused by the IPCC, stating that meeting the UNFCCC stabilisation objective is dependent not only on mitigation policy but crucially on the development path[60] in all countries. This has been highlighted by successive assessment reports of the IPCC as the driving forces of emissions are inherently linked to the underlying wider development path (Sathaye *et al*., 2007). While recognising the importance of a broad conception of driving forces Raskin *et al.* (2005) identified *culture, power and values* as the conditioning framework or '*ultimate drivers*' through which indirect socio-economic drivers such as population, economy and technology produce an environmental impact[61]. The discussion of driving forces, trends and mitigation in the literature, including AR5, has developed to encompass wider issues of social, cultural and governance factors. It is therefore conceptually erroneous to conceive mitigation, or indeed the in-

[57] CO_2 Emissions = Population X (GDP/ Population) X (Energy/GDP) X CO_2/Energy.
[58] The process of model building and implementation is inherently a social exercise and is therefore subject to bias, preferences and ideologies (Grunwald, 2011).
[59] Sometimes detailed as political and institutional factors, governance is a wide concept that encompasses state, civil society and market (Sathaye *et al*., 2007: 708).
[60]Sathaye *et al.* (2007) defined a development path; "…as a complex array of technological, economic, social, institutional, cultural, and biophysical characteristics that determines the interactions between human and natural systems…".
[61] O´ Mahony *et al.* (2013) discusses a synthesis of scenario driving forces which points to human agency and the social and cultural creation of governance, economy and technology.

trinsically linked concepts of human development (HD) and sustainable development (SD), with remove from social, cultural and governance dimensions. Driving forces can be unified in scenarios of national development pathways (Sathaye *et al.*, 2007), to explore both sustainable development and effective mitigation. In scientific inquiry they are used to explore and analyse future change and in strategic inquiry to envision desirable change (Alcamo, 2008). Development pathways can emphasise the multiplicity of possible outcomes, the multidimensional problem character and the power of human agency. For a development path to be sustainable in the long term wealth, resources, and opportunity must be shared for minimum standards of security, human rights, and social benefits, such as food, health, education, shelter, and the opportunity for self-development (Reed, 1996). From a mitigation perspective, the integration of wider issues of human development are essential in order to define sustainable development paths. Linking social and cultural factors is consequently intrinsic to a holistic perspective on development, and related mitigation. In expanding the explanatory power of the Kaya identity as a framework for emission scenarios, this is similar to the criticism of the EKC in that a wider conception of explanatory driving forces is necessary, some of which may not be quantified. The reductionist approach of the majority of models can therefore be complimented by the addition of these ´softer´ issues in hybrid quantitative and qualitative scenarios (O´ Mahony, 2014).

Human Development and Sustainable Development

The imperatives of environmental change and development needs led to the separate but complementary courses in development thinking of HD and SD (Constantini and Monni, 2008: 267). The concept of human wellbeing based on the capability approach of Sen (1979) found expression in the first Human Development Report (UNDP, 1990). The focus of HD was on the enlargements of freedoms and capabilities, thus diffusing attention away from "*economic growth, increased personal income, technological progress or social modernization towards the ends which are the liberties themselves*" (Sen, 1999). The environmental limits to economic growth proposed by Meadows *et al.* (1972) were reflective of an era where environmental pressures were increasingly evident and the attention of both methods and policy began to change. The concept of SD was defined by the Brundtland Report (WCED, 1987) as; "*development that meets the needs of the present without compromising the ability of future generations to meet their own needs*". This tension between sustainability and development (Jabareen, 2006) has been followed by an evolution of the concept of SD going beyond needs and environmental preservation, to the three 'pillars' of sustainability: environmental, economic, and social. This broad SD framework is equally relevant for rich countries concerned with economic growth, well-being, human development, and lifestyles and those less-developed countries where SD can play an active role in reducing poverty, achieving higher living standards and increasing human development levels (Constantini and Monni, 2008: 868).

As early ideological and perspectivist battle lines between development needs and environmental protection have to some extent dissipated, much of the focus moves to synergies and co-benefits[62]. Crucially, there are opportunities for HD while implementing mitigation as the concepts of HD and SD are now symbiotically linked.

[62] Notwithstanding inevitable conflicts and tradeoffs.

HD cannot be achieved without SD, in preserving a productive and benign environment and a sufficiently stable climate. A two-way relationship exists between climate change and sustainable development. The role of the environment in supporting HD has been progressively strengthened in the Human Development Reports and in definition of the millennium development goals (MDGs). There is now recognition of full integration of HD and the environment as mutually reinforcing development objectives. From a theoretical perspective, *integrated Sustainable Human Development* can be defined as development that promotes human capabilities in the present without compromising the capabilities of the future (Anand and Sen, 2000)[63].

Social and cultural dimensions

The objective of stabilising the global climate, now acknowledged as a maximum +2°C threshold, requires transformative change. In scientific and strategic inquiry this is commonly shaped as low carbon transition scenarios, with radical technological change, particularly towards renewables (Clarke *et al.*, 2014; Delucchi and Jacobson, 2011) and also efficiency. Maintaining energy services while eliminating GHG emissions is a conundrum that must be solved if modern civilisation is to develop and persist[64]. Important concepts from literature on decomposition analysis such as Tapio *et al.*, (2007) include *dematerialisation of production*, where efficiency per unit output is improved as a techno-fix, and *immaterialisation of consumption*. It is this latter concept, where well-being and economic growth are decoupled from energy consumption that is embodied in the concepts discussed here. While the technological transition is critically important[65], in mitigation it should neither be regarded as the primary nor necessarily the most critical factor. A dominant focus within national development policy on economic and technological development is unlikely to engender sustainable development as it ignores imperative and indivisible social and cultural dimensions[66]. The IPCC AR5 articulates the social dimension of mitigation primarily in terms of behaviour; as in efficiency and curtailment of energy use (Blanco *et al.*, 2014:51). This is a limited conception of what can and will influence mitigation in the long-term[67]. Shove (2003) describes the limitations of focussing on individual consumption and prioritises transformation of ´collective conventions´. Shove (2010) highlights the policy blind-spot as decision-makers are constrained to the frame of *attitude-behaviour-choice* (ABC). Effective mitigation requires that holistic integrated conceptions of mitigation policy and national development pathways must be front-and-centre. They must be inclusive of the primary importance of social and cultural driving forces.

A more holistic perspective on mitigation is to consider lifestyles. The IPCC TAR proposed that in the context of energy and emissions, behaviours and consumption should not be seen in terms of economic rationality (Toth *et al.*, 2001:638) as lifestyles are not economically but culturally rational and *"…the social and cultural dimensions of human needs and wants must be included in the theoretical approaches*". The modern Western cognition of the self as in-

[63] Based on a concept of *ethical universalism*.
[64] As a society that uses concentrated energy to perform advanced tasks such as powering industrial production, transportation and IT.
[65] It also offers opportunities for economic and human development in the ´green growth´ model.
[66] As described by Noble (1977, xxii) technology is a social process and one, albeit important, aspect of the development of society.
[67] Either by direct action on social and cultural dimensions or by passivity and omission of these dimensions.

dividual is “peculiar” within the context of world cultures and history, where the definition tends to be of “the self” as relational and interdependent. In this Western individualist-consumerist cultural identity lifestyle and consumption are a means of self-realisation through commodities and a cultural transition is necessary. The importance of lifestyle is reflected in the large differences between energy per capita across nations. Only partly explained by weather and wealth, it is attributed to different lifestyles, traditions and cultures (OECD/ IEA, 1997, Blanco *et al*., 2014: 50). Kónya and Ohashi (2007) have shown that even between high income countries, consumption shares have substantial heterogeneity. A study of consumption patterns and GHG emissions within Switzerland showed that low household emissions are characterised by less-spending on mobility and more on leisure and “quality oriented consumption” (Girod and de Haan, 2009). Weber and Perrels (2000) proposed an advance on modelling energy demand and emissions by including lifestyle factors. While this is a step forward it does not address the underlying social and cultural factors implicit in lifestyle, the causative factors of consumption. A continued focus on consumption as the end fails to analyse the underlying cause and will inevitably guide policy towards the end-of-pipe. At the analytical level, ´integrated´ or ´hybrid´ scenarios offer an approach to include social and cultural dimensions (O´Mahony, 2014). In analysis this can be implemented by exploratory or more normative backcasting scenarios. In policymaking this process can also be used, facilitating the integration of sustainable development strategy with development policy and the inclusion of underlying social, cultural and governance factors and objectives. Mainstreaming sustainability and mitigation would be assisted by the full integration of these macro development goals through related strategy and policy where holistic scenario approaches are used both to envision and analyse future transition and transformation. The predictive scenarios embodied in standard forecasts may also assist in this process of mainstreaming as they can animate the future consequences of current trends and dynamics. However, two limitations of predictive forecasts in the context of transition and transformation are that they don´t usually include the qualitative driving forces described above, and in addition, risk producing thinking entrenched in current dynamics of “solutions, possibilities and limitations” (Börjeson *et al*., 2006).

Human needs and consumption

The SRES (Nakicenovic, 2000:114) placed particular emphasis on the importance of Maslow´s hierarchy of needs (Maslow, 1943) in understanding economic and social development as a driving force of emissions. Choices are only possible once basic human needs have been met such as food, shelter, health care, safety and education. Development is not economically defined but framed as HD, the furthering of choices. Three essential choices are identified from UNDP (1997) as; to have access to resources needed for a decent standard of living, to lead a long and healthy life and to acquire knowledge. A value is also placed on many other choices from political, economic and social freedom, to opportunities for being creative and productive, and to enjoy human rights. The non-hierarchal and higher needs proposed in Maslow´s later work and also by Max-Neef (Maslow, 1970; Max-Neef, 1991), are now recognised as a more fruitful conception.

In neoclassical economics the concept of the rational consumer is one who chooses the consumption of goods to satisfy wants and desires. The pursuit of wellbeing is a search for better ways of satisfying individual and collective utility through consumption. Aside from meeting basic needs, it must be recognised that consumption can perform various functions; creating meaning (McCracken, 1988) and social positioning (Veblen, 1899). Gronow and Warde (2001)[68] pointed to other factors of convenience, habit and responses to social norms and institutional contexts. Modern economics has been wary of the terminology of needs (Jackson, 2003) due to the perceived politicised critiques of industrial development since the late 18th century (Marx, 1859)[69]. More recent criticism of needs-based arguments have claimed that they are unnecessary, naïve and moralistic (Baudrillard 1970; Douglas *et al.*, 1998). This position has been denigrated by numerous critics, in contrast to the 'insatiability' of desire, 'true' human needs are finite, few and universal (Max Neef, 1992; Maslow 1954, 1968). The critique has expanded as authors argue that modern consumerist based society has created a range of 'false' or 'unnatural' needs that alienate consumers from wellbeing and cause environmental damage (Fromm 1976; Illich, 1977). The consumer way of life is '*deeply flawed, both ecologically and psychologically*' (Wachtel 1983), failing to meet human needs and protection of the environment. Multiple independent lines of evidence support these assertions. The '*life-satisfaction paradox*' shows that real consumer expenditure has more than doubled in thirty years, but life-satisfaction has not followed (Donovan *et al.*, 2002). Myers and Diener (1996) found that people were marginally less happy despite considerably increased personal income. From a macro perspective, the more recent work of Max Neef (1995) proposed the threshold hypothesis, that: "*for every society there seems to be a period in which economic growth (as conventionally measured) brings about an improvement in the quality of life, but only up to a point—the threshold point—beyond which, if there is more economic growth, quality of life may begin to deteriorate*". Kasser (2002) showed that materialism has a cost in terms of individual wellbeing. As material commodities are poor satisfiers of social and psychological needs, materialism therefore can directly hinder wellbeing. Wilkinson and Picket (2010) have linked materialism with inequality, a strong concern of the debate on SD. From a macro perspective, Kubiszweski (2013) showed that in the last 40 years as GDP increased, indicators of progress have stagnated or fallen in many countries. In addition, in the process of consumerism, consumers are 'locked- in' to unsustainable consumption with little individual control (Sanne, 2002). In the 21st century it appears that Hardin´s parable *´The Tragedy of the Commons´* (Hardin, 1968) has become the *´Tragedy of Consumption´*.

Maslow (1954) put forward a model of human motivation based explicitly on a finite set of universal human needs, categorised as; material needs (for subsistence, security and protection), social needs (for status, self-esteem and belongingness) and 'growth' needs (such as truth, understanding, aesthetics, justice, and meaning). While Maslow (1968) abandoned the hierarchy of needs for a duality with material and higher needs side-by-side, his work has been influential, inspiring needs-based approaches and the development of humanistic psychology. Max Neef (1991) set out a typology of satisfiers, pseudo-satisfiers and violators which can impede the meeting of needs. Consumption is more nuanced than an assumption of insatiable wants and desires, and consumerism cannot meet all needs or all dimensions of wellbeing. While there is general agreement on the centrality of consump-

[68] For a review see Jackson (2005).

[69] As noted by Anand and Sen (2000), there is no essential conflict between the history of economic literature and HD as including this indivisible dimension "*reclaims an old and established heritage, rather than importing or implanting a new diversion*." Such concerns are there since the foundations of modern economics but have been overlooked by the preoccupation with commodity production, opulence and financial success.

tion to individual and societal cultural identity (Toth *et al.*, 2001), the crystallisation of an accepted set of principles, although theoretically possible, appears to have been arrested. Jackson (2003) offers a way forward through the utility of the distinction between different types of needs and intrinsic links to the discourse of SD. If social and psychological needs can be hampered by modern commodities, then increased wellbeing is possible with reduced consumption[70]. Jackson (2005) is adamant in stating the importance of the hegemony of consumption, and given its influence on cultural identity, policy-making inevitably must engage with what Miller (1995) termed the '*vanguard of history*'.

Wellbeing and sustainable consumption

The study of ´*sustainable consumption*´ became a field in own right after the Earth Summit in 1992. These studies were neatly summarised by Weber de Morais and Schluter (2009) as shaping individual action in *ecological modernisation* and *social psychological* approaches and collectively shaping actions through *systems of provision*[71]. Ecological modernisation is connected with concepts of efficiency and social psychological perspectives with persuasion to change attitudes[72]. The social- psychological approach may also attempt to encourage lifestyle change and the boundaries are fluid. Both of these approaches have been the focus of government policy intervention (Seyfang, 2009). It is the third option that actually engages with the ´vanguard of history´ and attempts fundamental change of the social structures influencing consumption, but it receives little policy attention. It is paramount to recognise at this juncture that both carbon lock-in (Unruh, 2000) and consumer lock-in (Sanne, 2002) should create urgent priority in addressing the fundamentals of consumption, the paradox of increased consumption and emissions and reduced wellbeing. This has particular salience for developing countries which are in the process of developing middle class lifestyles but can achieve this without adopting the consumerist values of developed countries (Blanco *et al.*, 2014: 11). It is likely that the alternative to addressing these root causes is higher emissions development paths, higher costs of mitigation, increased environmental damage and lower wellbeing.

The Jevons rebound effect has relevance here, particularly where there are indirect energy service requirements of shifting consumption to other goods and services. Druckman *et al.* (2010) offer an important insight into the implications of time use for carbon emissions, where categories such as eating and drinking and personal care have far higher footprints than social time or caring for others. In terms of social choice, this relates both to individual utility and broader social welfare. Individual utility could be related both to hedonic and eudaimonic wellbeing and may therefore favour the inclusion of subjective measures of wellbeing as life satisfaction or "happiness", an empirical approximation to "experienced utility" (Kahneman *et al.*, 1997), a wider conception than utility solely from consumption. Recognising the role of society in consumption and wellbeing: i) as consumer

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[70] From a methodological perspective, this is linked to the *immaterialisation* concept from decomposition analysis discussed earlier, where the wellbeing derived or indeed the output produced is decoupled from material or energy consumption.
[71] From Shove (2004) and Seyfang and Paavola (2007).
[72] Weber de Morais and Schluter (2009) offer the examples of energy efficiency labelling for the former and advertising to promote public transport for the latter.

lock-in can limit choice between alternatives, and, ii) social and environmental variables such as equality and public or environmental goods play an important role in wellbeing, the valuation of consumption utility and sustainability in welfare functions are notable considerations. The "life satisfaction approach" of Frey *et al.* (2004) used statistical techniques to investigate how subjective well-being varies with income on one hand and public goods on the other, in contrast to the stated and revealed preference approaches common to environmental economics. As an approach to economics, this relates to the "consilience"[73] of Wilson (1998). Gowdy (2005) argued that welfare policies based on broader measures of well-being than mere per-capita income are more likely to move society toward environmental and social sustainability.

An evolution by social and cultural transformation is required for the national development paths underlying low carbon technological transition to move towards sustainability. This is described by SEPA (2012) as the '*third way,*' focussing on human welfare and change that is beneficial to quality of life while also reducing emissions at source. Weber de Morais and Schluter (2009), describe this potentially normative concept as the *´double dividend´* of less consumption and improved wellbeing[74]. A general perception that mitigation and sustainability entail a decline in quality of life (SEPA, 2012) is prevalent, counter-productive and according to the evidence, a tragic canard from the stable of Hardin (1968). The focus of development in general must be moved to concepts of human wellbeing and welfare to begin to grasp the opportunities for HD implicit in mitigation. This would not be described as *´sustainable consumption´* but as *´integrated sustainable human development,´* where consumption of resources is just one component of wellbeing. The focus of this development model is beyond what we would define as *´green growth´* or indeed *´green society´*. It is has as a centrality HD, where the pursuit of sustainability is implicit and consumption is a means not an end. The related objectives of mitigation, environmental protection, economic growth and sustainable development function in supporting roles[75].

Transformation frameworks in research and policy

While recognising the sensitivities and dilemmas in arriving at increased wellbeing and more sustainable consumption, the necessity to reduce consumption levels has been endorsed and the role of government intervention is highlighted (Mont and Plepys, 2008: 531). The urgent social and cultural transition (ISSC/UNESCO, 2013) could be assisted by shifts towards postmaterialism and self-realisation (Inglehart, 2008). This could transfer consumption and the use of time to categories of activities that have inherently lower energy service requirements as outlined by Druckman *et al.* (2010). If lower energy prices result by reducing demand, this would require attention to the potential for the rebound effect. However, as discussed by Gillingham *et al.* (2014), the rebound effect though real is often an order of magnitude less than what would be required for ´backfire´ to overwhelm the improvement.

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[73] "Consilience" is the linking of facts and fact based theories across disciplines to create a common groundwork for explanation (Wilson, 1998).

[74]An example of this transition in terms of lifestyle is change to a diet of lower meat consumption in developed countries. This supports better health outcomes, lower emissions and environmental impacts, increased global food supply and food security and reduced food expenditure for all consumers.

[75] Notwithstanding the inevitable conflicts and tradeoffs in balancing sustainability, this does not attempt to resolve ideological contestations between the *anthropocentric* and *ecocentric* approaches to sustainability.

Given the relatively recent historical emergence of consumerist society and the damage implicit, it would appear naïve to assume that it will continue in perpetuity[76]. Operationalising transformation requires further research to determine actions that enhance wellbeing while reducing emissions. How transition could be implemented[77] also requires further inquiry with the ultimate objective to actualise wellbeing, in tandem with cost and environmentally effective mitigation. The breadth of transdisciplinary scope, the dearth of research and the potential to advance wellbeing and mitigation renders the overarching subject ripe for a new research programme. While some attempts have been made (Jackson, 2003; Jackson, 2005, SEPA, 2012), little empirical research has explored the link between quality of life and emissions. Potential frameworks to explore links include Maslow (1968), Max Neef (1991) and Nussbaum (2000). Concrete actions require definition and existing studies have outlined some potential actions that enhance wellbeing and reduce emissions including; environmental education (Toth *et al*., 2001:639), relationships, local community and mindfulness[78] (Brown and Kasser, 2005), time affluence that facilitates more intimate close relationships, more time for physical activities and personal development, and more mindfulness of living in the present (Kasser and Sheldon, 2009). The implementation of such approaches could be achieved through such indications as environmental policy, environmental legislation (Toth *et al*., 2001: 638-640) or institutional theory (Weber de Morais and Schlüter, 2009). Allwood *et al.* (2011) focussed on material efficiency as the source of sustainability and pointed to innate human greed as a barrier to modifying consumerism[79]. Jackson (2005) offers that competitive self-interested behaviours do not have a unique role in human evolution. Gowdy and Krall (2013) draw on ample literature with solid scientific evidence, that cooperation and altruism are pervasive in nature and humans are uniquely social mammals. Through cooperation humans have evolved the traits that define our species[80]. A similar apparent pessimism to the greed metaphor is represented in the perception that mitigation involves sacrifice of quality of life (SEPA, 2012). This also appears as a significant fallacy as the focus can move from wealth to wellbeing, and from material consumption to the ´good life' and one of the emerging basic principles of sustainability is wellbeing (Sathaye et al., 2007). Weber de Morais and Schluter (2009: 8) make a strong case for opportunities to implement the double dividend of reduced consumption and increased wellbeing. This is a prevention not cure approach by seeking to address causes and not symptoms. At a macro level, the threshold hypothesis of Max Neef (1995) is a useful concept in understanding when diminishing quality of life returns from economic growth may turn to stagnation or deterioration. In deve-

[76] It could be argued that the *age of enlightenment* and *the romantic period* are historical examples of social and cultural transformations. A more specific contemporary example is the recent reduction in the number of smokers in developed countries.
[77] Including the political feasibility of this transformation. However, it must also recognised that failure to intervene will validate the continuation of a detrimental cycle of consumer lock-in, hampered wellbeing and related environmental damage.
[78] The government of the United Kingdom is now exploring the use of mindfulness in policy in the All-Party Parliamentary Group on Wellbeing Economics.
[79]Allwood *et al.* (2011) propose that no prosperous nation has ever chosen to constrain material acquisition. However, anthropology is overflowing with collective and individual examples, with social and cultural movements towards the arts, science, education, nature, spirituality, community, altruism, philanthropy and other pursuits of non-material growth. National examples of change include war-time re-engineering of economies providing a central purpose above that of acquisition.
[80] Language, culture, technology, and complex social structure.

loped countries this is pertinent in modifying development objectives. It is also germane in developing countries in understanding where growth at all costs is concerned "*all that glisters is not gold,*" and can come with high social and environmental costs. It also has economic costs where the productive base of the economy is undermined or growth itself is unsustainable[81].

Discussion and conclusion

The field is littered with unanswered questions (SEPA, 2012) which have significant implications for the intertwined issues of HD, SD and mitigation. However, it is paramount to remember that energy per capita varies substantially between and within nations based on social and cultural factors and also that consumption in many cases is not supporting wellbeing. This shows that different states are both possible and desirable. Engaging this is potentially significant both to successful future mitigation in meeting climate change targets and also to wellbeing of society in both developed and developing countries. The achievement of improved quality of life and reduced consumption will involve action across society and governance. Policy-intervention is required and integration of related development strategies for economy, sustainability, mitigation etc. is a prerequisite, and must be based fundamentally around wellbeing and HD at its core. The 'third way' approach involving *integrated sustainable human development* can shift focus to human wellbeing and human development and away from consumption. The concepts involved relate to some of the key debates in the economic literature. The threshold level hypothesis of Max Neef (1995) supports the view that quality of life may be hampered by economic growth. The EKC hypothesis is not currently supported for energy and carbon emissions which may follow other patterns such as an N-shape. In the case of the rebound effect, this is a relevant consideration but evidence suggests it may not be significant enough to backfire and further research would be of benefit.

A continued focus on the consumer and consumption in both analysis and policy appears to be peculiar when acknowledging the intricacies of HD and the consequences for wellbeing and the environment. Operationalising these concepts in analysis can be achieved by developing the wellbeing components of energy models and implementing hybrid qualitative and quantitative scenarios as a vehicle to integrate social and cultural driving forces (O´ Mahony, 2014). Fundamental change requires that the underlying social structures influencing consumption receive policy attention. A general progression in research and policy is now urgently required towards societal transformation and low carbon transition. This is paramount, as the human development dimension of mitigation is now as inseperable as the human thumbprint on the climate itself.

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[81] UNEP (2011) have suggested that "green growth" offers a stronger and more resilient path than BAU "brown growth" in the medium to long term. A number of countries which pursued high growth in the construction sector prior to the recession in 2008 are examples of unsustainable growth that ultimately damaged economic prospects.

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