SUSTAINABLE DEVELOPMENT CONFERENCE 2022

10-12 NOVEMBER 2022

BANGKOK, THAILAND

CONFERENCE PROCEEDINGS

Tomorrow People Organization

Dušana Vukasovića 73, Belgrade, Serbia

www.tomorrowpeople.org

Proceedings of international conference:

"SUSTAINABLE DEVELOPMENT CONFERENCE 2022"

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Producer: Tomorrow People Organization

Publisher: Tomorrow People Organization

Quantity: 200 copies

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SDConference Proceedings 2022 ISBN: 978-86-87043-85-5

Architecture as a Catalyst in Mitigating Heat Island Effect

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ABSTRACT

With the increased rate of expansion of urbanization and urban sprawl in the recent years, the environmental issues faced by urban places become ever more concerning. The heat island effect has prejudicious effects on the environment as well as on the dwellers. Urban heat Island effect, which is generally caused due to the replacement of natural land cover with dense concentrations, the research paper will help in understanding whether and how architecture plays a role in mitigating the heat island effect. Architecture has a definite role to play in the mitigation of the urban heat island effect: cities are defined by their buildings and make up a large part of the built environment. The choices that architects and planners make can have a huge impact on the size of a city's urban heat island. (Munro, 2012) Questions of sustainability and environmental consequences pervade most aspects of our lives. In architectural practice, they influence our building regulations and our energy codes. (Thomas, 2015) The research paper is an attempt to review various cases across the world where architecture – both buildings and spaces affect a city's urban heat and also review the factors that help to develop resilient architecture in the context of climate change.

KEYWORDS: *Urban heat island, Architecture, Environment, Climate change, Design strategies*

 ISBN: 978-86-87043-85-5

1. INTRODUCTION

Due to replacement of natural terrain and land cover with dense accumulation of built mass like pavements, buildings and other surfaces that absorb and retain heat brings up an effect called “urban heat islands”.(Learn About Heat Islands: Environmental Protection Agency, 2022)Urban heat island effect has been consequently associated with additional environmental effects like Urban canyon effect – which occurs as a result of trapped heat on streets due to construction on both sides, and dust dome effect – a phenomenon in which soot, dust, and chemical emissions from human activities and vehicles get trapped in the air above urban spaces.(Munro, 2012)Due to urbanizing trends in society, a greater number of populations is shifting towards urban areas which is eventually increasing the demand of housing and amenities in the urban areas. People expect to seek new opportunities and improve their lifestyle. Even though urban development and infrastructure satiate number of amenities to the people, but it also comes up with long-term ramifications. Though urbanization comes up with its own prospects, but the dark side of the urban development needs to be thrown light upon. The increased prevalence of environmental issues caused due to urbanization cannot be compromised with economic and social stability. Architecture and urban infrastructure being the main cause for the occurrence of these phenomena, we intend to entail architecture as a part of the solution in mitigating the heat island effect.

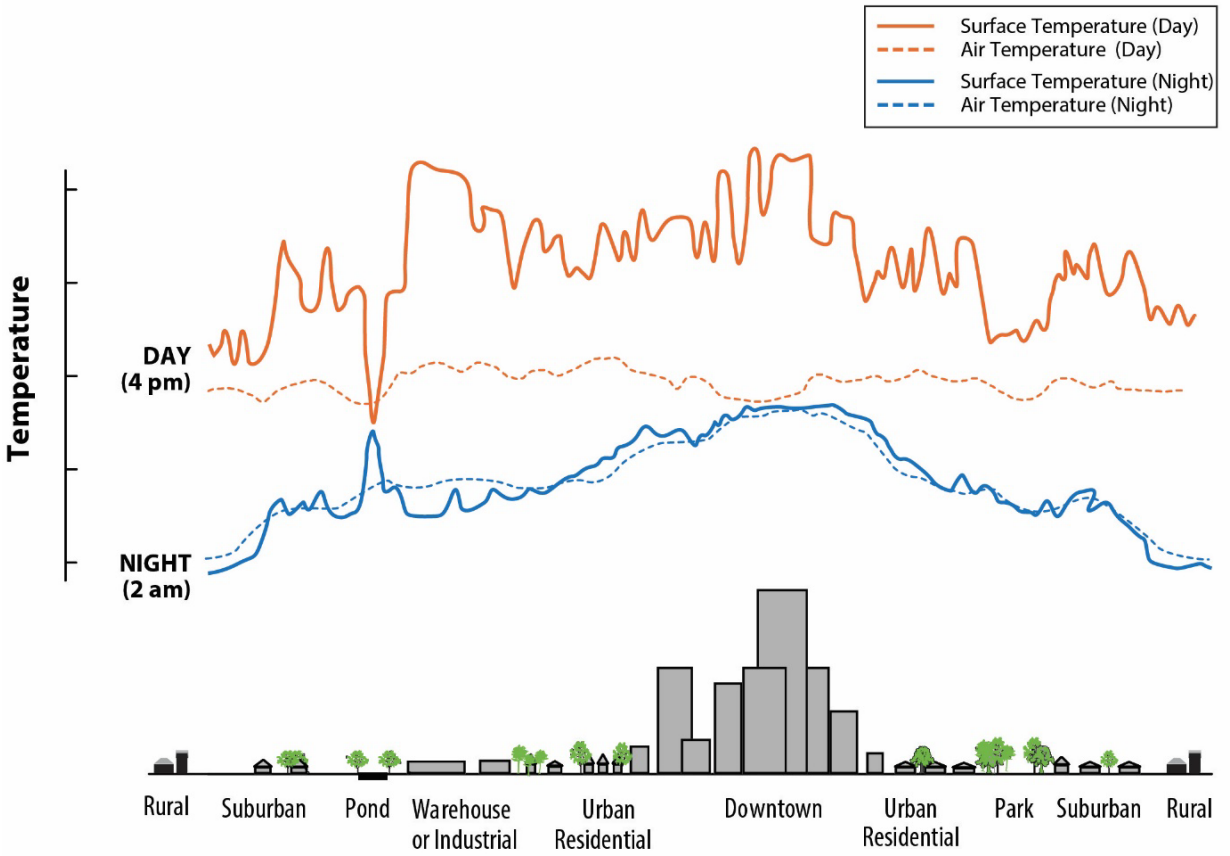

Figure 1: Day and Night-time temperature variations in various regions (Source: US Environmental Protection Agency)

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2. METHODOLOGIES

2.1 Study through various cases around the world, in which architecture –
- 2.1.1 - affected the urban heat island effect
- 2.1.2 - mitigated the urban heat island effect

2.2 Understanding views of experts in the field regarding role of architecture in mitigating urban heat island effect.

3. IMPACT OF URBAN HEAT ISLAND EFFECT

Urban spaces experiencing this effect eventually experience higher daytime temperatures, reduced night-time cooling, and higher air-pollution levels. Due to which the demand for electricity elevates. Electricity which is typically sourced from fossil fuel power plants, lead to increase in air pollutants and greenhouse gas emissions. As the infrastructure gets more complex and denser, the way for the trapped heat and pollutants to escape or dilute becomes too narrow. The increased temperature on ground level eventually leads to ozone layer zone formation usually identified by smog which contributes to complex air quality problems. Sensitive population become vulnerable during such conditions. All humans are physiologically affected in different ways by prolonged exposure to heat, which frequently exacerbates pre-existing illnesses and causes risk of premature death and disability. (WHO, 2018) Heat islands effect cause excessive and abrupt increase in temperature due to which the burden on water, energy, transportation, food, and livelihood security elevates resulting in power shortages or even blackouts. According to WHO, between 2000 and 2016, the number of people exposed to heat waves increased by around 125 million. These heat islands thus become catalysts for it to intensify and have harmful and threatening effect on the environment as well as the people. (Learn About Heat Islands: Environmental Protection Agency, 2022)

4. CASE STUDY OF NEW YORK – urban environment where urban heat islands have affected the environment and people.

A heat island effect exists in New York City, with mean temperatures in the NY Central Park (NYCP) Station typically higher than the surrounding stations, ranging from 1.20°C to 3.20°C, according to an analysis of temperature differences over time between the NYCP station and 23 regional weather stations classified according to distance and level of urbanisation.(Rosenthal, Knowlton, Rosenzweig, Goldberg, & Kinney, 2003)NYC experienced heat wave conditions majorly in the month of July which is considered to be the hottest month of the year; the highest air temperature above 32.22 °C (90 °F) on roughly more than half of the month for which the local meteorological office issued heatwave warnings.(Ramamurthy, González, Ortiz, Arend, & Moshary2, 2017)Urban environments are dominated by constructed surfaces, which have a high thermal inertia and a large ability to store heat. After nightfall, the heat that has been stored is released as sensible heat, accelerating the urban-rural thermal gradient. The inner-city areas experience greater UHI

 ISBN: 978-86-87043-85-5

values than the neighbourhoods close to the coastal areas. The UHI intensity is amplified due to the spatial pattern to local dynamics and land cover characteristics. According to study conducted by New York City Community Air Survey (NYCCAS), the most significant predictor of monthly average minimum temperatures was greater level of development, followed by distance to coastline and that it might take a green cover above a baseline level and reduction of impervious surface such as asphalt, tar and building materials that absorb most of the sun's radiation for temperature to drop.

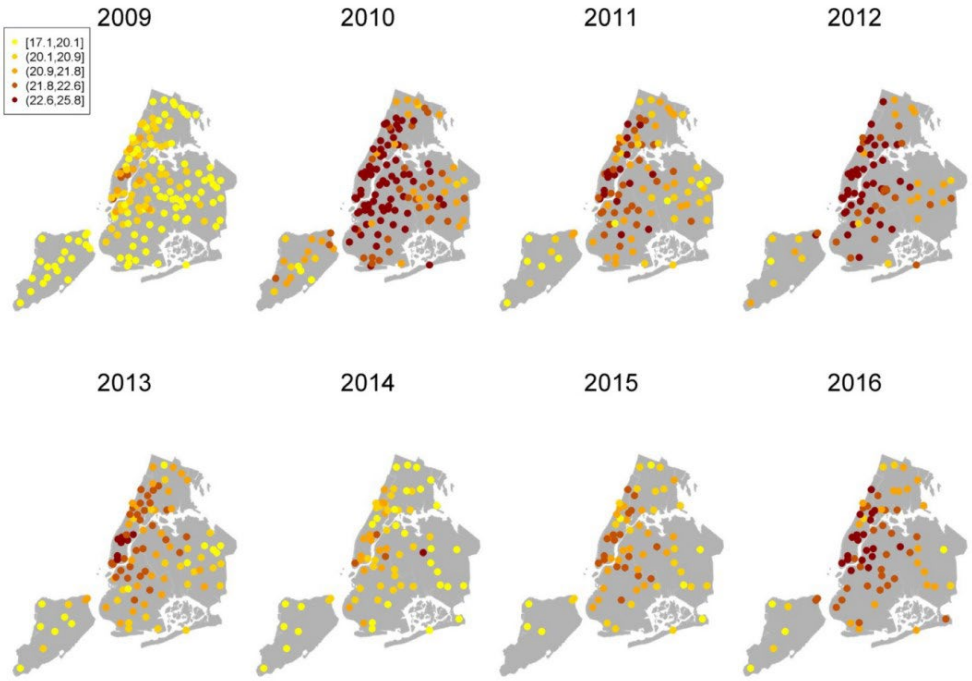

Figure2: New York map of temporally adjusted summer average temperature by year (Johnson, Ross, Kheirbek, & Ito, 2020)

5. ARCHITECTURAL FACTORS RESPONSIBLE FOR URBAN HEAT ISLAND EFFECT

5.1 Impervious surfaces: Vegetation when replaced by impervious surfaces like asphalt and concrete for roads, buildings, and other structures lead to increase in surface temperatures and ambient temperatures, as a result of materials that absorb heat from the sun rather than reflecting it.(UCAR, 2022)

5.2 Size and shape of cities: Cities are significantly different in shape from rural places in terms of aerodynamics. Tall structures serve as barriers and slow down winds.(UCAR, 2022)

5.3 Reduced natural landscapes in urban areas: Reduction in the number of trees, plants, and water bodies that would otherwise serve to cool the air by shade, water transpiration from plant leaves, and surface water evaporation, respectively.(Learn About Heat Islands: Environmental Protection Agency, 2022)

 ISBN: 978-86-87043-85-5

5.4 Urban Geometry: Wind flow and the potential of urban materials to both collect and release solar energy are influenced by the size and arrangement of structures inside a city. Surfaces and structures that are blocked by nearby buildings in densely populated places evolve into huge thermal masses that are difficult to dissipate heat from. Cities with plenty of narrow streets and tall structures can turn into urban canyons that can prevent the cooling effects of natural wind flow. (Learn About Heat Islands: Environmental Protection Agency, 2022)

5.5 Dark Surfaces: A black material absorbs all light energy and transforms it into heat, which causes the thing to warm up. Dark surfaces, like those used in construction, therefore absorb solar heat, and amplifies urban heat island effect.(Penny, 2019)

5.6 Air conditioning: Buildings with dark surfaces heat up more quickly and need more air conditioning to cool them down, which takes more energy from power plants and produces more pollution. Additionally, air conditioners heat the local area by exchanging heat with the outside air. Urban heat islands are therefore growing as a result of a cascading effect.(Marar & Gupta, 2022)

6. ROLE OF ARCHITECTURE IN MITIGATING THE HEAT ISLAND EFFECT

The urban heat island effect will only expand as the world becomes more urbanised, and architecture will have a greater challenge—and obligation—to play a substantial role in its mitigation. The decisions that architect, designers, and planners make about these new roads, buildings, and cities will have a significant impact on the quality of life for the people who live there, from the air they inhale to the electricity costs they pay to the climate they experience. This is true throughout the globe as the natural environment keeps making way for the built environment.
Understanding how the structures and spaces that are designed affect a city's urban heat is important for the profession of architecture to mitigate the effect of the urban heat island. Sustainable building design has been primarily focused on the internal environment of the building, whereas designing out urban heat islands will require consideration of the external ramifications of designs, so architecture's response to mitigating urban heat islands needs to be distinct from its environmental response. It is necessary to comprehend how choices in external cladding, construction materials, glazing placement and size, building shape, and geometry affect the urban heat island effect in a region. In the efforts to make each city unique, it is crucial that architects should be aware of the effect of the design on the environment. Their materiality and design, however, is a significant contributor to the urban heat island effect.(Munro, 2012)

6.1 Use of materials with low thermal mass: One of the main contributors to the urban heat island effect is concrete, which has a large ability to retain heat and is referred to as a "high thermal mass" material. To help minimize the heat island effect and protect the environment, the use of highly reflective materials like glass or metals should be reduced.(Tiwari, Karmakar, & Sharma, 2021)

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6.2 Cool Roofs/ Green Roofs: About 25% of a city's surface area is comprised of roofs, therefore the heat they absorb and release, significantly affects the city's temperature.(Akbari & Levinson, 2008) Replacing the conventional concrete roofs which absorb 90% of the sun's heat energy, with a light-coloured roof/ greener roof which will only absorb 10% or less will significantly impact on the heat transferred inside the building and thus reducing the artificial air conditioning demand.

6.3 Landscaping: The urban heat island effect was first brought about by as a result of natural environment being destroyed to make way for the constructed environment. Thus, reintroducing vegetation in horizontal as well as vertical elements effectively spread across the buildings and urban public spaces would help in reducing urban heating. Increased use of green elements could significantly reduce the impact of the urban heat island effect. Vegetation at street level can be employed to mitigate the urban heat island effect where green roofs and living walls are not suitable equally effectively. (Munro, 2012)

6.4 Street plantations: Urban heat island effect can be significantly reduced by street level landscaping. Trees that are close to a building may significantly affect the need for air conditioning by affecting both the interior and outside temperatures of the building.(Munro, 2012)

6.5 Improving the urban geometry: The streets should be made wider to increase circulation, and they should be supported by vegetation to prevent adjacent buildings from blocking the air in the narrow streets.

6.6 Reducing dark coloured surfaces: Some cities are "lightening" their streets to reduce urban heat islands. This is accomplished by applying a highly reflecting grey coating to the dark rooftops, parking lots, and streets made of black asphalt. Urban air temperatures can be drastically lowered by these modifications, particularly in the sweltering summer months. This can lessen the urban heat island effect, which is caused by the black body effect.

6.7 Vernacular methods of building construction: Utilizing readily available, environmentally friendly materials along with unique construction methods can improve the area's attractiveness while simultaneously minimising the consequences of urban heat islands.(Tiwari, Karmakar, & Sharma, 2021)

6.8 Building envelope and shading devices: This concept, known as "Cool Building Envelopes," describes a building envelope that can decrease the amount of radiant heat that is stored and, as a result, minimise the amount of heat that is emitted into the environment. The Cool Building Envelope concept not only reduces traditional energy use but also protects the environment from pollutants and serves as a strategy to combat urban heat island.(Elhinnawy, 2005) In the urban environment, shading devices block incoming solar radiation from surfaces like the urban floor, seating spaces, building façades, and rooftops and successfully maintain their temperatures lower.(Vartholomaios & Kalogirou, 2020)

6.9 Effective and efficient electrical appliances: Utilizing energy-efficient equipment and appliances can lessen the heat island effect by reducing greenhouse gas emissions from electrical appliances. The heat island effect is reduced by the efficient use of energy-saving

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appliances, which release lesser greenhouse gases into the atmosphere. (Tiwari, Karmakar, & Sharma, 2021)

6.10 Rain gardens and swales: Storm water attenuation benefits majorly from Sustainable Urban Drainage Systems (SUDS). Swales and rain gardens are examples of SUDS that catch storm water and enable it to slowly seep into the ground. They give water extra time to evaporate since they hold onto it for a longer amount of time. By integrating vegetation, rain gardens perform evapotranspiration as well, significantly cooling the air.(Jolma Architects, 2018)

7. CASE STUDY OF COPENHAGEN: Urban environment where urban heat islands have been mitigated using architectural strategies.

On the hottest day in Copenhagen in 2010, surface temperatures up to 47 degrees were recorded; nevertheless, the temperature was 12 degrees lower outside the city. As part of the city's comprehensive climate plan, Copenhagen has created its own climate adaptation strategy in response to rising sea levels, more rainfall, and a warmer city centre. By reducing CO2 emissions by more than 20% over the past ten years and ensuring that 30% of its energy supply comes from carbon-neutral sources, Copenhagen has already reduced its environmental footprint. To reduce rainwater run-off, more green spaces, such as "pocket" parks and green walls and roofs, have been added. In addition to capturing 60% of rainfall, green roofs help enhance air quality, plant life, and wildlife habitat while minimising the effects of urban heat islands.(About: ENVIRONMENT Eco-Innovation Action Plan, 2010) Copenhagen seeks to alter its current urban layouts to make better use of energy. Retrofitting is the process of renovating historic structures with an eye towards energy efficiency. Old windows are replaced during renovations, and insulated walls, doors, and roofs are built. Solar panels and green roof gardens are additionally incorporated. Copenhagen not only constructs infrastructure but also protects its green spaces. It is considered a successful method of lowering the city's surface temperatures and helps lessen the impact of the urban heat island. (Sustainability: Urbanlife Copenhagen, n.d.) According to the European Environment Agency, roughly 60% of the Copenhagen region is covered in impermeable materials, which leads to many difficulties during periods of heavy rain. Therefore, all of these green spaces that make up Copenhagen's green infrastructure are storm water management solutions with the primary goal of reducing the strain on the sewage system. Copenhagen's green infrastructure contributes to cooling off the city during heat waves.

 ISBN: 978-86-87043-85-5

Figure 3: Sustainable strategies to mitigate urban heat islands in Copenhagen (Copenhagen Urban Lab Executive Summary, 2020)

8. INNOVATIVE STRATEGIES

A new field of study in the reduction of the urban heat island effect has been evolving. Innovative strategies with subject to materiality, coatings, technologies, planning processes, policies, etc. can be looked up to develop mitigating techniques for urban heat islands.

8.1 Sponge cities: A recent AI-based study measures cities' resilience to climate change by comparing the number of trees and lakes they have to how much concrete they contain. Urban areas that include plenty of natural features, such lakes, parks, and trees, as well as other well-designed structures meant to soak up rain and prevent flooding, are known as "sponge cities." In order to promote sponginess and provide additional advantages, such as cleaner air, habitat for wildlife, and places to escape the summer heat, many cities are developing green spaces. The Sponge City theory places a strong emphasis on the fundamental ideas of 'based on nature', 'source control', 'local adaptation', 'protecting nature', 'learning from nature', preserving urban ecological space to the greatest extent possible, regenerating biodiversity, and creating a beautiful landscape environment. (Harrisberg, 2022)

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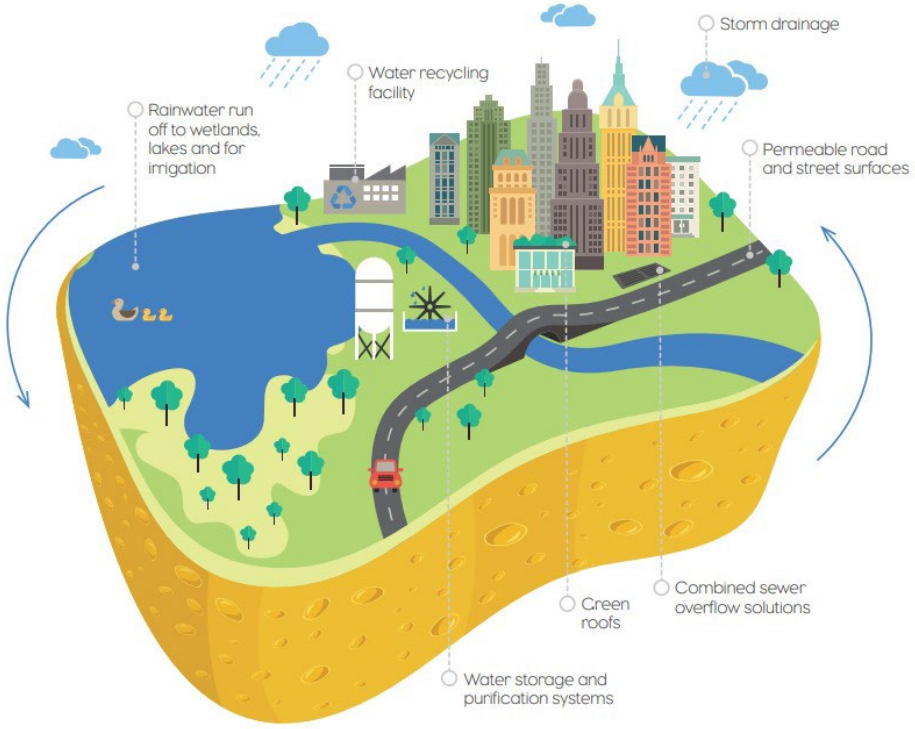

Figure 4: Module of a sponge city (Source: China-Britain Business Focus)

8.2 Thermo chromic materials and coatings: A substance that offers a remedy to one city might not make much of a difference to another. Innovative materials like thermo chromic, for example, have the ability to reduce urban heat islands on a scale greater than just one city. The importance of thermochromism and thermo chromic materials in a wide range of applications, including energy-efficient building constructions, the textile industry, thermal or heat storage, maintenance processing, and sensors, makes them of great interest. Buildings would be constantly changing, with all facades having slightly varying colours throughout the day, changing completely from morning to evening.(K, et al., 2022)

8.3 Retro reflective materials: Retro reflective materials have been proposed as a creative way to lower the amount of energy needed for cooling while also enhancing urban microclimates. Regardless of the direction of incidence, retro reflective materials have the capacity to reflect incident energy back towards its source.(Pérez, Castro, Melo, & Xamán, 2017)

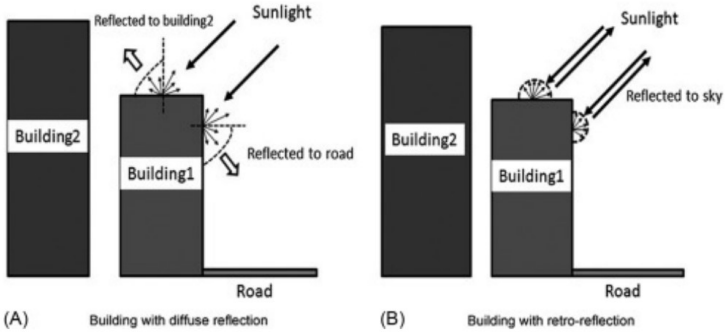

Figure5: Difference between diffuse reflection and retro-reflection (Pérez, Castro, Melo, & Xamán, 2017)

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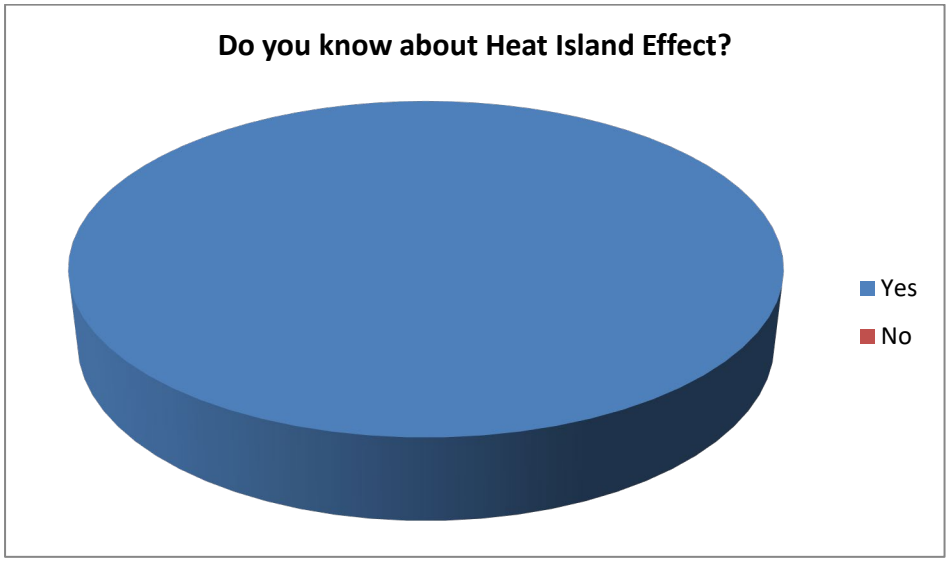
8.4 Cool roofing strategies: A cool roof technology system integrates smart sensors with rainwater harvesting systems to reduce attic and roof temperatures for increased occupant comfort. (Yew, 2021) TARC, or temperature-adaptive radiative coating, was created by researchers at the Materials Sciences Division of UC Berkeley with the intention of assisting in the achievement of this objective of zero electricity use and zero emissions.(Sander, 2022)

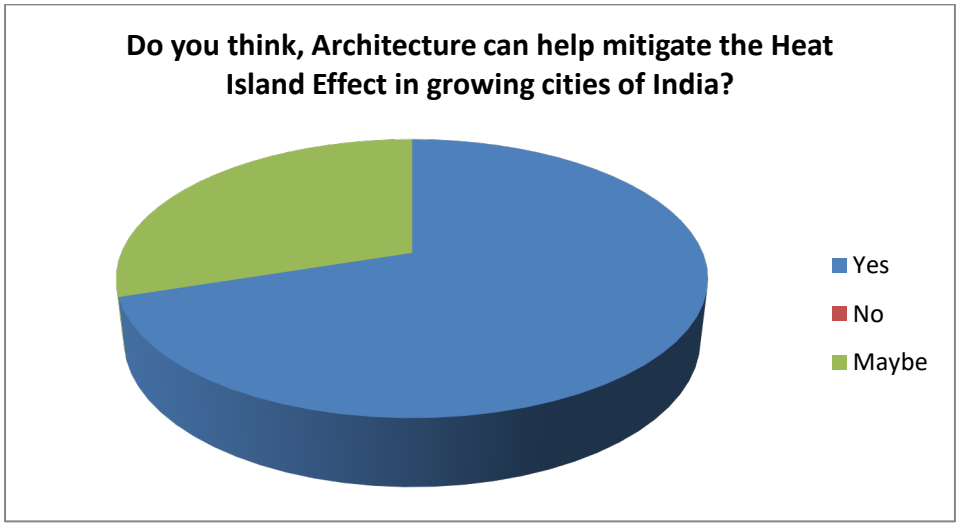
9. EXPERT'S OPINIONS, SUGGESTIONS AND VIEWS THROUGH INTERVIEWS AND QUESTIONNAIRE

To understand the expert's perspective about this research, a chosen sample of 10 respondents were identified and interviewed. The respondents are practicing architects, professors with a background of Environmental & sustainable Architecture. The respondents were asked *three* questions for which the following responses were recorded.

Do you know about Heat Island Effect?



Do you think, Architecture can help mitigate the Heat Island Effect in growing cities of India?



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What ways do you think Architecture contributes as a catalyst towards mitigating the Heat Island Effect?

The responses from the respondents can be summarized as follows:

For centuries, traditional Architecture has revolved around building in context with response to local climate & context, with focus on using traditional construction methods and materials. In several cases, self-shading blocks, mutual shading, low-rise and high density designs have typically addressed concerns that could create the issue of heat island effect. Architects like Charles Correa (at the Belapur housing, arts and crafts museum), B V Doshi (Madhya Pradesh Electricity Board Housing, Aranya Housing), Achyut Kanvinde (Most of his institutional campuses) and others have carefully created designs which not only have respected the built but also the unbuilt as well. Climate and context responsive architecture are a key towards addressing the growing concerns of heat island effect. Careful planning decisions at city level, implementing urban design guidelines that address the development of the built and the unbuilt, will help mitigate the growing temperatures of city core areas. (Source: responses from respondents)

10. FUTURE SCOPE OF RESEARCH

The following research suggests that both, Architecture and the role of Architect, can substantially contribute towards designing of the future built environment, which will have lesser environmental impact and the resultant heat island effect can also be addressed. Detailed studies about preparing guidelines for development can further be carried out as an extension to this research and it shall help evolve a better assessment matrix of the heat island effect.

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 ISBN: 978-86-87043-85-5

Riverdale Country School

Case Study of the Effects of Urbanization and Exposure to Green Space on Mental Health

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 ISBN: 978-86-87043-85-5

Abstract

10.7% of people globally have suffered from mental illness, anxiety being the most prevalent. Shockingly, rates of depression have rapidly increased over the years, with a shocking 63% jump between 2009 and 2017 in young adults. What if this rapid increase in mental illness correlates with a seemingly unrelated topic, urbanization? With the growth in urbanization in most countries around the globe, there has been a substantial loss of green space, and with that, the worsening of our environment. Recent studies have shown that there might even be another consequence: the lowering of one's mental health. The connection between these two seemingly unrelated concepts might actually reveal the damages done by urbanization that cannot be seen with our eyes. In this paper, I analyze the relevant scientific literature examining the relationship between mental health and the environment in over 12 studies. I look at four factors in the literature; (1) the definition of mental health used in research papers, (2) the methods, (3) the results, and (4) the studies' limitations in order to draw connections and attain the most accurate interpretation of the broader literature. Through the thorough analysis of the works, I find that there is indeed a correlation between the growing loss of exposure to green space and the worsening of one's mental health and overall wellbeing. This paper focuses on the different ways researchers have approached a common mystery and reveals how the relationship between mental health and urbanization is more complicated than what meets the eye.

Keywords: Urban agriculture, Urban farming, Mental health, Green space, Urbanization

 ISBN: 978-86-87043-85-5

1. Introduction

Urbanization, the process whereby more and more people come to live in a concentrated area which leads to a city, has been present all throughout our history and is taking place even today. What began in ancient Mesopotamia at approximately 7500 BCE has evolved drastically. Due to modernization, there has been great technological advancement that drives the development of buildings, apartments, factories, and streets, all of which need land. In Ghana's capital city, Accra, the urban built environment has expanded from a shocking 55.1% to 83.79% at the expense of green spaces, which have declined from 41% to 15% over the last 27 years (Pulampu and Boafo, 1). This decline in the natural environment because of urbanization prompted global issues such as deforestation, endangerment of species, and unclean air quality. Moreover, scientists have found that urbanization may also have an impact on a person's mental health.

Mental health is a very complex subject and a very layered word in itself. What was once understood as having a mental disease, mental health is now defined as "a state of complete physical, mental, and social well-being and not merely the absence of disease of infirmity"(Manderscheid, 2). Because of the variety of definitions of mental health throughout time, it is important to note that research papers may assess different forms of mental wellness. However, this vast array of the interpretations of mental health could actually increase the accuracy of the common thread of the collection of papers by seeing how urbanization impacts all aspects of mental health. There is extensive empirical literature on the association between exposure to nature and mental health, so in this narrative review, I will discuss the methods I used to assess the strength of the evidence from recent experimental studies, the concreteness of its results, as well as the limitations of the studies.

 ISBN: 978-86-87043-85-5

2. Methods

In order to corroborate a conclusion from recent studies, I needed to collect an extensive amount of experimental research papers. In total, I reviewed and analyzed the methods and results of over 12 scientific studies. Two vital pieces of information I paid close attention to were the ways scientists approached the assessment of mental health and the methods in which they attained their results. The way scientists in the experimental studies define mental health is critical because this variation in the way scientists approach the topic of mental health may convince readers to cast doubt on the findings; however, this difference may actually reinforce the results of the studies because it shines light on all aspects of mental health no matter which definition is used. If the results in the variation of papers show a significant correlation between the exposure to nature and the definition of mental health they choose to use, there is a very high chance that the results of the papers are linked together under the large category of mental health. Secondly, the methods in which the scientific papers obtain their data is vital because there could be limitations that are reinforced based on how scientists choose participants for their surveys or how exposure to green space is assessed.

2.1 Assessment of Mental Health Findings

Generally speaking, mental health is split into two spheres: mental illness and mental wellness. Mental illness refers to conditions that affect cognition, emotion, and behavior (eg. schizophrenia, depression, autism) (Manderscheid, 3). On the other hand, mental wellness focuses on overall mental happiness and life satisfaction. Based on which dimension the authors of these scientific papers focused on, the scales used to assess mental health will be different. For instance, in the scientific paper, *The Impact of Urbanization on Nature Dose and the Implications for Human Health* (Cox, Daniel T.C., et al., 2018), the scientists chose to approach mental health as more diagnosis-based, thus choosing mental illness. The specific

tool they used to assess this was the "Depression, Anxiety, and Stress Scale" or the DASS 21. This scale was measured by a 4 point system where respondents "rated the extent to which seven statements applied to them over the previous week"(Cox, Daniel T.C., et al., 2018). The total scores would stretch from 0-4, mild cases of depression, to 14+, extremely severe cases of depression. The key to this scale is the use of the word depression and anxiety, which serves to diagnose the respondent after they answer the list of questions. Similarly, the scientists behind *The Effect of Air Pollution and Rural-Urban Difference on Mental Health of the Elderly in China* (Tian, Tao, et al., 2015) chose to focus on mental illness but by using a different scale: the Center for Epidemiological Studies Depression Scale (CES-D). The scale measured the depression degrees of respondents based on their answers to 10 questions based on the China Health and Retirement Longitudinal Survey (CHARLS). If the CES-D score was higher, it meant that the respondent would be more depressed. Thus, the purpose of the scale is to diagnose each of the respondents.

Unlike the previous two papers, the study described in *"Happiness in the Air: How Does a Dirty Sky Affect Mental Health and Subjective Wellbeing?"* (Zhang, Xin, et al., 2017) focused on the mental wellbeing aspect of mental health. They further classify wellbeing into two subgroups: hedonic happiness and evaluative happiness. Hedonic happiness refers to "moment-to-moment experienced utility and directly links to immediate emotions and affection, while evaluative happiness, such as life satisfaction, reflects an overall assessment of the entire life and therefore is less likely subject to short-term changes in external environment"(Zhang, Xin, et al., 2017). To measure both of these, the study uses the China Family Panel Studies (CFPS), a national representative survey of Chinese communities. The respondents must answer questions given by the CFPS that measure Subjective Well-Being (SWB) such as, "Overall, how satisfied are you with your life?" The respondents must answer on a scale of 1(not satisfied) to 5(very satisfied), and then these answers reflect "the

extent to which people's own experiences match their long-term aspirations and expectations about their lives as a whole"(Zhang, Xin, et al., 2017) instead of diagnosing the respondent.

2.2 Assessment of Methods Findings

Factoring in such different scales used to measure mental health, all 12 studies I have evaluated assessed their respondents with a common tool: surveys. Although some researchers such as those who conducted the study in *The Effect of Urban Nature Exposure on Mental Health-A Case Study of Guangzhou* (Liu et al. 2021) proceeded with face-to-face interviews, others such as scientists behind *Living in Grey Areas: Industrial Activity and Psychological Health (Marques and Lima, 2011)* conducted online surveys. It can be assumed that the most efficient way to measure one's mental health is through surveys and questionnaires. The sample size of the respondents in a total of 12 evaluated scientific papers, including the previous listed studies, ranged from 1,546 to 387,195 people. Each of the 12 research papers were hyper focused and conducted in specific parts of the world such as Guangzhou, China, the Netherlands, and more, which could affect how many participants the scientists could include in their data collection. Similarly, the age groups of the participants varied, as some researchers such as the ones in *The Effect of Air Pollution and Rural-Urban Difference on Mental Health of the Elderly in China* (Tian et al. 2015) wanted to focus on specific age groups such as the elderly. Another essential component of the study was to calculate what classified as an urban environment or rural environment, and how scientists could pick participants based on which type of society they lived in.

In the study *Associations of Combined Exposure to Surrounding Green, Air Pollution, and Traffic Noise on Mental Health*(A.H.Janssena, et al., 2019), the researchers used 2 different metrics to assess surrounding green space: Normalized Difference Vegetation Index (NDVI) and the National Land-Use Database of the Netherlands of 2010 (TOP10NL). The TOP10NL categorized sections of the Netherlands into different classes of land-use such as

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water, terrain, etc. Based on these two tools, this study categorized the extent to how urbanized the land that the participants live on was. In contrast to how this study assesses green space, *The Impact of Urbanization on Nature Dose and the Implications for Human Health* (Cox, Daniel T.C., et al., 2018) used another form of survey in which they trust the participants to accurately describe their surroundings. The survey participants in this paper completed the Nature Relatedness Scale, which required them to answer their individual differences in connections to nature. These questions assessed affective, cognitive, and experiential relationships individuals have with the natural world.

3. Results

Although each study conducted their own experiment and used their own unique methods, the relationship between mental health and urbanization are very evident in their conclusions. Generally speaking all 12 studies showed a strong correlation between a decrease in exposure to nature and a decrease in overall mental health. According to *The Impact of Urbanisation on Nature Dose and the Implications for Human Health,* which focused on mental illness, “people in more built up areas were more likely to perceive that they had better physical health, but were increasingly likely to suffer from depression compared with their rural counterparts”(Cox et al. 2018). Furthermore, they found that “people who choose to spend time in nature more often, and for longer, are healthier across multiple dimensions of health”(Cox et al. 2018). People in heavily urbanized environments with a low nature dose (exposure to greenspace) tended to have worse mental health and lower perceptions of social cohesion. Additionally, for studies that focused on mental wellbeing, access to large parks was positively associated with all aspects of well-being. For instance, in *Happiness in the Air: How Does a Dirty Sky Affect Mental Health and Subjective*

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Wellbeing?, scientists found that a higher API (air pollution which is a by-product of urbanization) “significantly increases hedonic unhappiness”(Zhang et al. 2017). Finally, one of the most pronounced results in all 12 studies was in the study, *Associations of Combined Exposures to Surrounding Green, Air Pollution and Traffic Noise on Mental Health*, which stated that the “prevalence of poor mental health in the most urbanized areas was twice as high as the prevalence in the least urbanized areas”(Klompmaker, Jochem.,et al., 2019). Thus, based on the results of all the studies, there seems to be a strong connection between mental health and the environment.

3.1 Inconsistencies/Limitations in Data

Although there seems to be a notably strong correlation between the two topics, there were some inconsistencies between some of the research papers based on the demographics of their participants. For instance, in some studies that encompassed a wide range of age groups, researchers found that there was an overrepresentation of the elderly, which could have influenced their results and made it slightly different than other studies. Additionally, some studies found that women were more impacted by lack of green spaces than men, which was not touched on by other studies. Lastly, one study found that high urbanization versus extremely high urbanization does not seem to affect mental health in people, which is not stated by other studies. It is important to note that although there seems to be clear correlation between studies, that there are inconsistencies as well that must be taken into consideration.

These inconsistencies in the data can also be influenced by the limitations of the studies. Because mental health is such a complex subject and can be influenced by a variety of factors that have nothing to do with exposure to nature, there are many limitations that should be taken into account. Firstly, social demographics can influence what type of occupation a person has and how much income they have, which can then in turn affect a

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person's life satisfaction. Secondly, a person's socioeconomic status and family stability can influence their mental wellbeing and their happiness. These things can all come together and influence a person's mental health on top of the level of urbanization the area they live in is. These limitations are important to keep in mind so that studies in the future can factor these in before in order to create more effective surveys or experiments. Limitations are unavoidable in the research field and it is crucial to build on top of them in order to improve accuracy.

4. Discussion

Despite these limitations, the connection between a decrease in mental health and an increase in urbanization is evident in all the research papers that were analyzed. The establishment of this relationship is very critical because before research was conducted on this correlation, urbanization was presented as dangerous to people based on external consequences such as species extinction and deforestation. However, one of the biggest threats of urbanization is actually shown to be inside the mind of people as proven by multiple studies. Mental Health is proven to be a rising global issue as the rates of young adults who have a mental health disorder are rising each year at rapid rates. This increase coupled with the growing rates in urbanization and development can only have negative outcomes. Based on this research, scientists should look into urban farming techniques such as hydroponic gardening or community gardens, to help those who live in heavily urbanized areas gain access to green spaces to combat this rising issue. If the government cannot stop the spread of urbanization and the destruction of green spaces, they can help combat it by providing their people with access to parks, gardens, and other natural spaces.

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 ISBN: 978-86-87043-85-5

Economic Growth (GDP) and Electric Power Consumption: Synergy Trend Analysis of Geospatial Regions of the Global Economy: BRICS countries, United States, European Union, Latin America and Caribbean region, and the Countries in Fragile and Conflict-Affected Situations

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Abstract: This article includes global synergy trend analyses based on the World Development Indicators published by the Work Bank. The focus of the study is on economic growth (GDP) and electric power consumption. In order to understand globalization and regional developments, it is good to understand global and regional trends and the interactions between spatial trends. The synergy analysis tool was developed to analyze the synergy between two different trends, but it can be used to analyze simultaneously the synergy between three trends representing the three different dimensions of sustainable development. It is good for decision-makers to be aware - not only of the development of the trends themselves, but they should be aware also of the interactions between the trends. There may be positive, negative or no synergy between trends. These three different forms of synergy are therefore always possible. That is why this study is important and interesting for a broader audience. The research delivers synergy analysis results of electricity consumption in relation to global GDP in the main regions of the world: (1) the BRICS countries, (2) the United States, (3) the European Union, (4) the Latin America and Caribbean region, and (4) the Countries in Fragile and Conflict-Affected Situations. This analysis is a unique synergy analysis study and all empirical results are first time published in this study. This study provides many results, which are relevant for global policy-makers and especially for the World Bank and for the United Nations.

Keywords: BRICS countries, countries in Fragile and Conflict-Affected Situations electrification, electricity consumption, European Union, global GDP, Global trends, synergy analysis, USA, Latin America and Caribbean region, World Bank Data Base, World Development Indicators.

Introduction

In this empirical study, we shall analyze synergy trends between GDP and electricity consumption in world regions. Electrification is said to be the “new oil” in the world and it is also the key phenomenon of the global energy transition. We elaborate on the global electrification phenomenon in relation to global economic growth. Our methodology is a synergy analysis of these two key trends (economic growth and electricity consumption). There various background research articles in this field [1, 2,3,4,5,6,7,8,9]. Key articles linked to global sustainability discussions can be found in [10, 11, 12, 13, 14, 15, 16, 17, 18].

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The methodological framework of synergy analysis

When we analyze trends, scenarios or weak signals we typically analyze dynamic social and economic systems. One key aspect of trend analysis is nowadays the interlinkages of trends. This study focuses on the issue of interlinkages of global trends. The data of the study is from the World Bank´s Global Development Indicators database [19].

The Synergy Index is calculated in the following technical way (Data analysis phases in Steps 5-6) above: We can calculate the conventional index number of synergy and average long-run synergy index (see for example [1, 2]). It can be said that there exists a synergy between two factors when their combined effect is greater or smaller than the sum of their separate effects. In a mathematical form this can be expressed as

$$z = ax + by + cxy + d. \quad (1)$$

where x, y and z are variables and a, b, c and d are coefficients that determine how the output z depends on inputs x and y. In this case, we assume a time-invariant system, where the parameters remain constant. If y is 0, the output is determined by x and the coefficients a and d. Coefficients a, b and d determine the impact of the single inputs on the output. The synergy of the inputs x and y is determined by the component cxy, i.e. the co-effect of both inputs. The idea of synergy indicates choosing variables x and y such that an increase in the value of both variables x and y is desirable and refers to a commonly accepted direction of sustainable development. If we look at a change from A to B in Fig. 1 (from the original state xy0 to x1y1) we can determine the change in the area (Δz) to be

If we look at a change from A to B in Fig. 1 (from the original state x0y0 to x1y1) we can determine the change in the area (Δz) to be

$$\Delta z = a\Delta x + b\Delta y + c\Delta x\Delta y = y0\Delta x + x0\Delta y + \Delta x\Delta y. \quad (2)$$

We can interpret the synergy of the inputs to be determined by the shaded area in Figure 3, which equals ΔxΔy. The synergy can also be negative, as is shown in Fig. 3 where the change in y is negative and ΔxΔy becomes negative. This is a trade-off situation: when one factor increases the other factor decreases. In Figure 3. we have presented 3 basic forms of synergy between two variables.

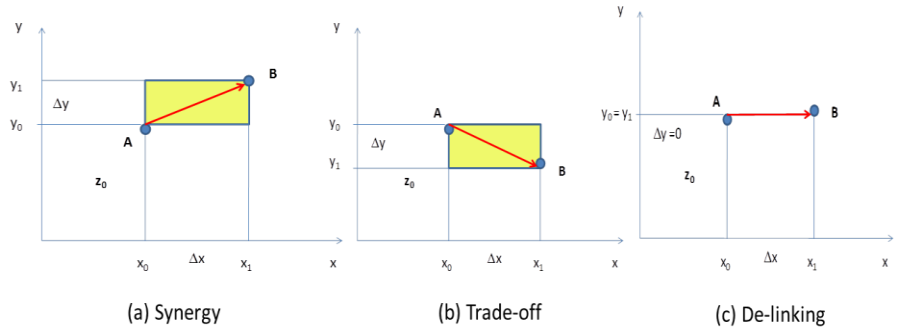

Figure 1: The alternatives of synergy level between two variables, x and y.
The alternatives of synergy level between two variables, x and y.

(1) Maximum synergy can be obtained when relative changes Δx and Δy are equal.

(2) In case the change in y i.e. Δy is larger than changes in x i.e. Δx, the quotient must be inverted to estimate the potential synergy ratio.

(3) Therefore, potential synergy/trade-off between two variables can be measured between -1 to +1.

(4) Where the negative sign indicates a trade-off between two variables.

Thus, the synergy level can be positive, negative or there is no synergy at all (de-linking). This idea can be applied in health care and industry field, but maybe in other industrial context contexts, too. Interpretation of the results is straightforward: the closer the calculated synergy factor is to 1 the stronger the synergy between the two (or three) variables can potentially be, and the closer the ratio is to −1 the potential for a trade-off is

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stronger. When the synergy factor is close to 0 there is delinking between the trends. This kind of analysis does not imply that synergy is necessarily good and the trade-off is bad, or vice versa. Such interpretation is case specific; to interpret the results in more depth, we need to determine how we would like the trends to involve.

The results of synergy analyses in global regions

BRICS countries

In this section, we report the key results of synergy analysess in the BRICS countries. In Fig. 1 we visualize the long-run synergy trend between GDP and electric consumption in Brazil. The synergy trend line is reported in Fig. 2. It is a slightly upward-sloping trend curve.

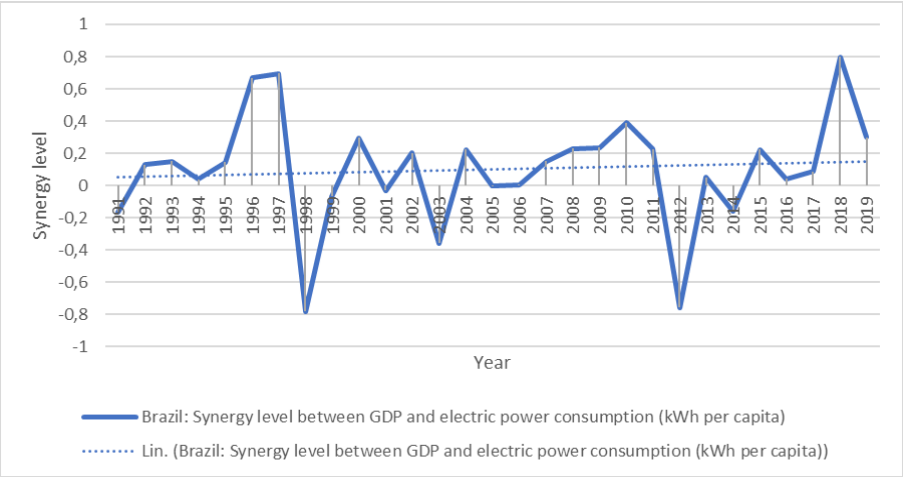

Figure 2: Brazil: Synergy level between GDP and electric power consumption (kWh per capita).

In Fig. 3 we report the histogram of synergy level observations level between GDP and electric power consumption (kWh per capita) in Brazil.

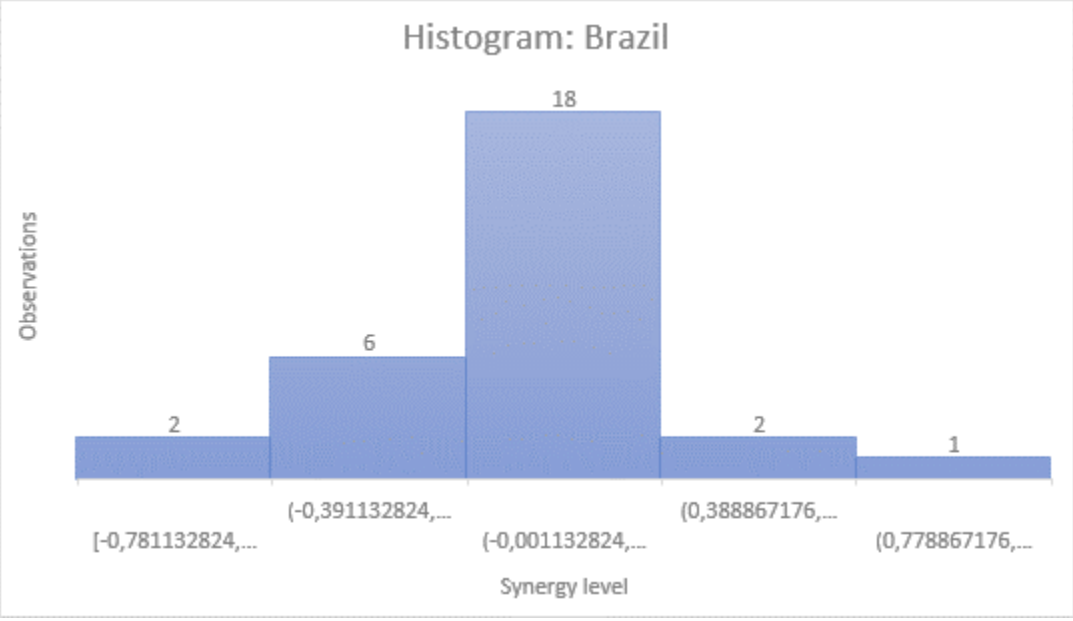

Figure 3: Histogram. Brazil. Synergy level observations level between GDP and electric power consumption (kWh per capita).

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In the case of Brazil, synergy observations are mostly in between -0,001-+0,39 (18 observations). We see that this histogram graph follows almost the conventional shape of normal distribution, however having a slightly negatively skewed distribution.

In Fig. 4 we report the synergy trend line of the Russian Federation.

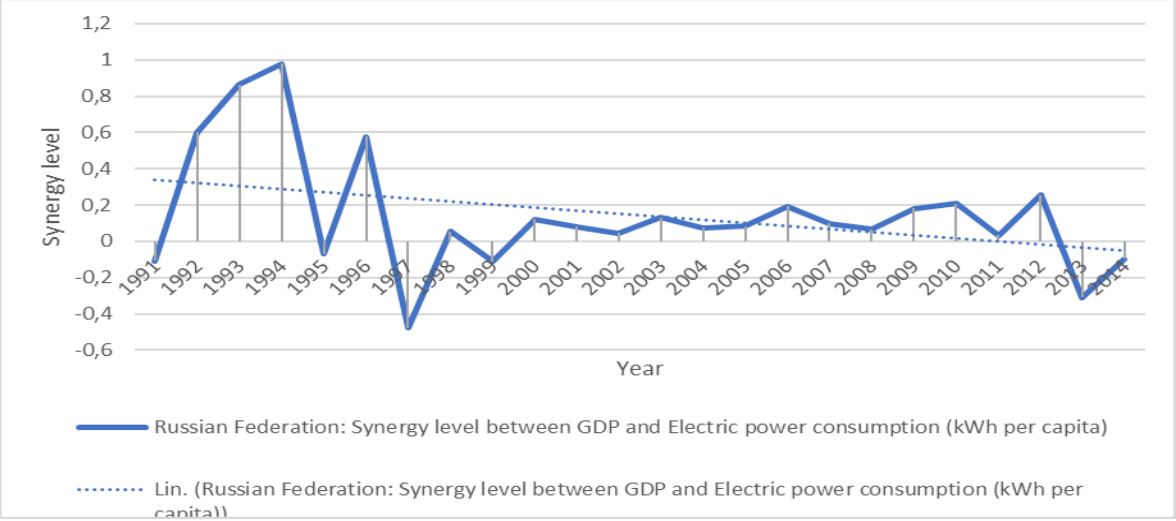

Figure 4: Russian Federation: Synergy level between GDP and electric power consumption (kWh per capita).

Key finding is that synergy trend in the Russian case is negative in the long-range. In early 1990s it was positive, but in the end of 1990s, it started to turn to very low positive level. In years 1997 and 2013 is reached negative synergy levels.

In Fig 5 we report a histogram graph of the Russian Federation. Synergy observations are mostly in between --0,07-+0,32 (15 observations). This figure 5 reports a left-skewed distribution. There is positive synergy between analyzed trend variables, but only on very low synergy level.

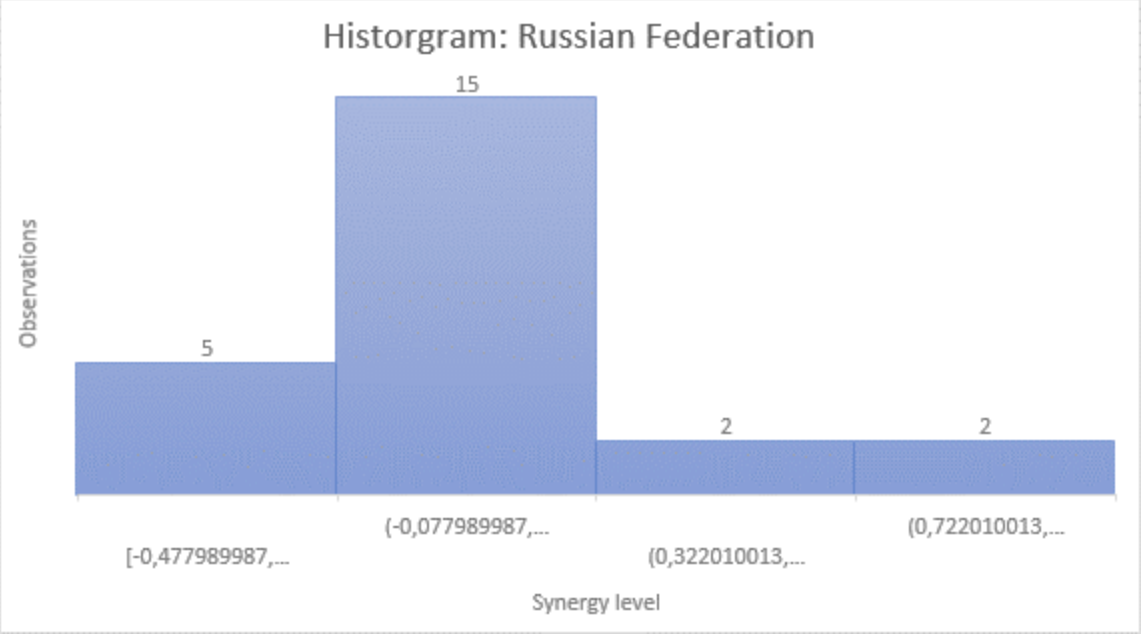

Figure 5: Histogram. The Russian Federation. Synergy level observations level between GDP and electric power consumption (kWh per capita).

In Fig. 6 we report synergy level between GDP and electric power consumption (kWh per capita) in India. The linear trend is stable and has very low synergy level in this case.

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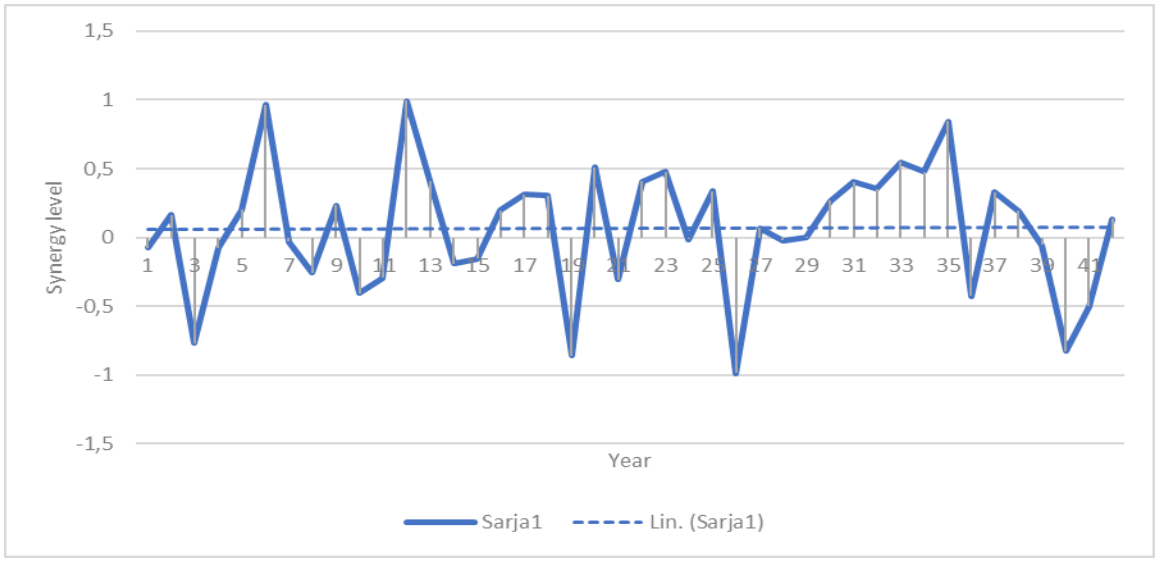

Figure 6: India: Synergy level between GDP and electric power consumption (kWh per capita).

In Fig. 7 we report a histogram of synergy observations in the statistical data analysis of India. We can observe at a distribution of observations is almost normal and only slight negative skewness can be observed. Most observations are between -0,06 - + 0,39 (18 observations).

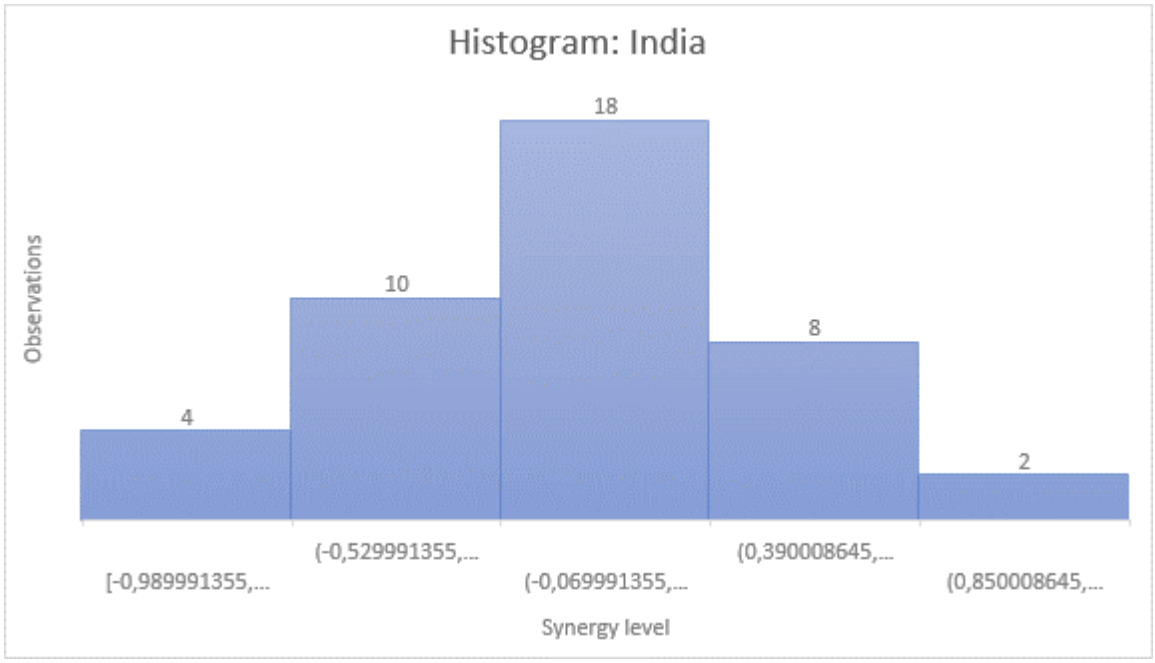

Figure 7: Histogram. India. Synergy level observations level between GDP and electric power consumption (kWh per capita).

In Fig. 8 we report a synergy trend level between GDP and electric power consumption (kWh per capita) in China. In this very special Chinese case, we see a clearly rising trend curve.

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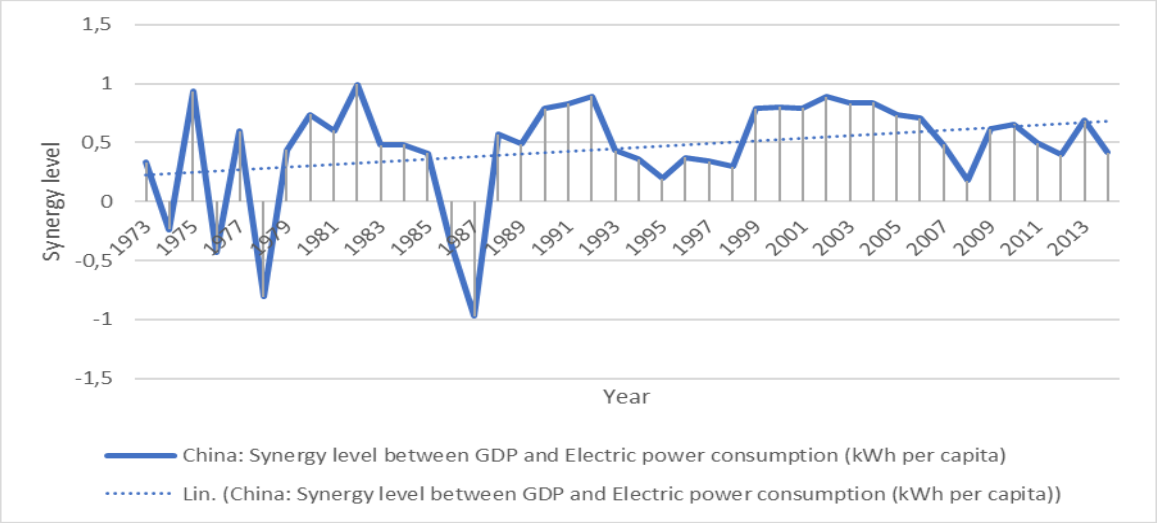

Figure 8: China: Synergy level between GDP and electric power consumption (kWh per capita).

The histogram of synergy observation is reported in Fig. 9. We see that histogram is positively skewed in the case of China. Most synergy observations are between +0,35 - +0,79 (21 observations).

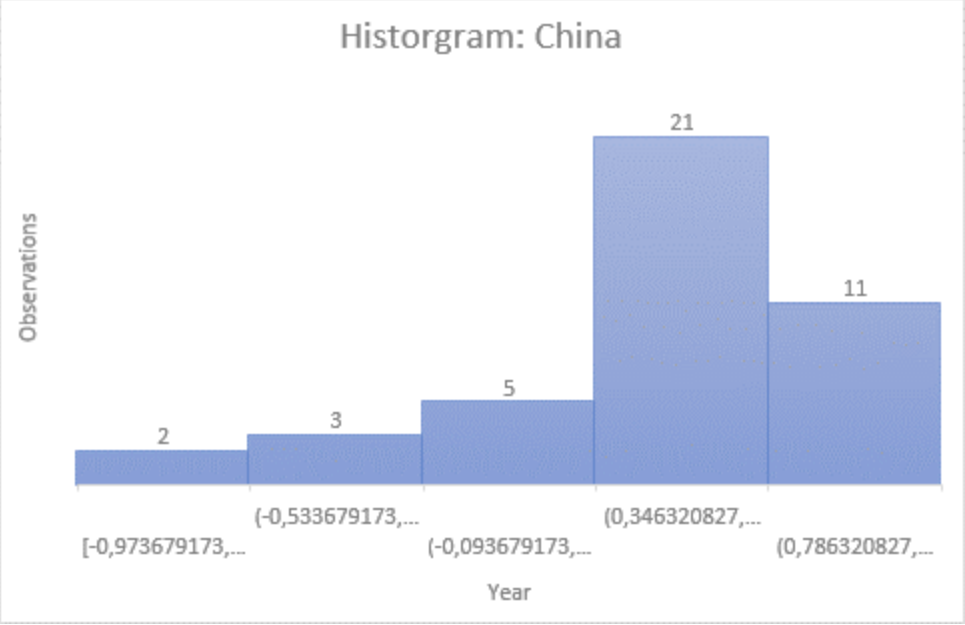

Figure 9: Histogram. China. Synergy level observations level between GDP and electric power consumption (kWh per capita).

Figure 10 shows the trend curve of synergy development in South Africa. It is a slightly ascending trend curve, but average synergy level is not very positive, less than + 0,02.

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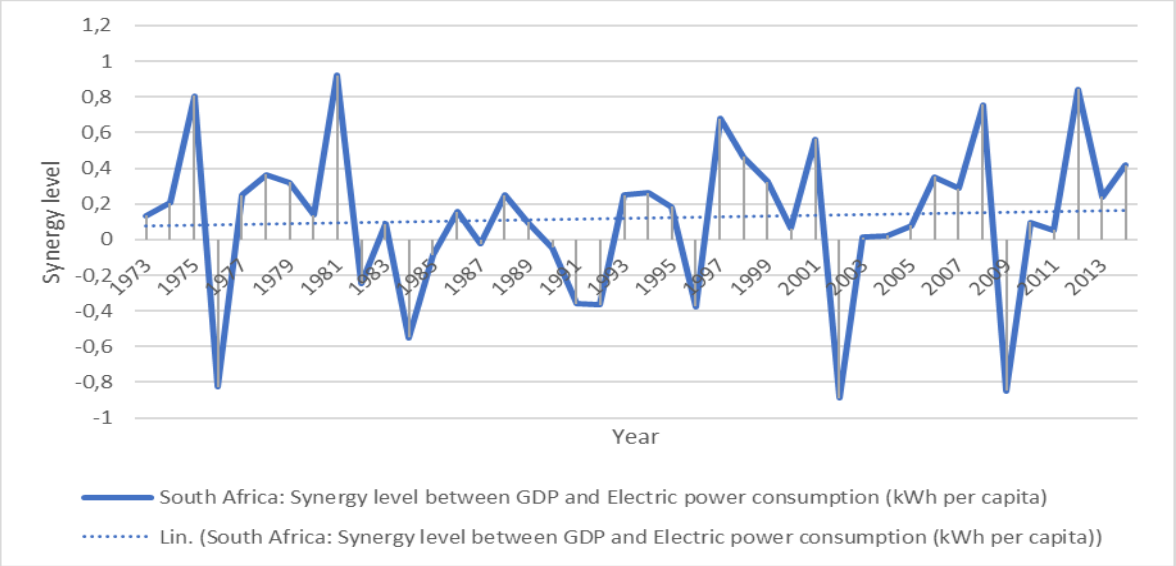

Figure 10: South Africa: Synergy level between GDP and electric power consumption (kWh per capita).

In Fig. 11 we have reported a histogram of South Africa, in which the distribution of observations is quite normal. Most of the synergy observations fall between -0,02 - and +0,40 (24 observations).

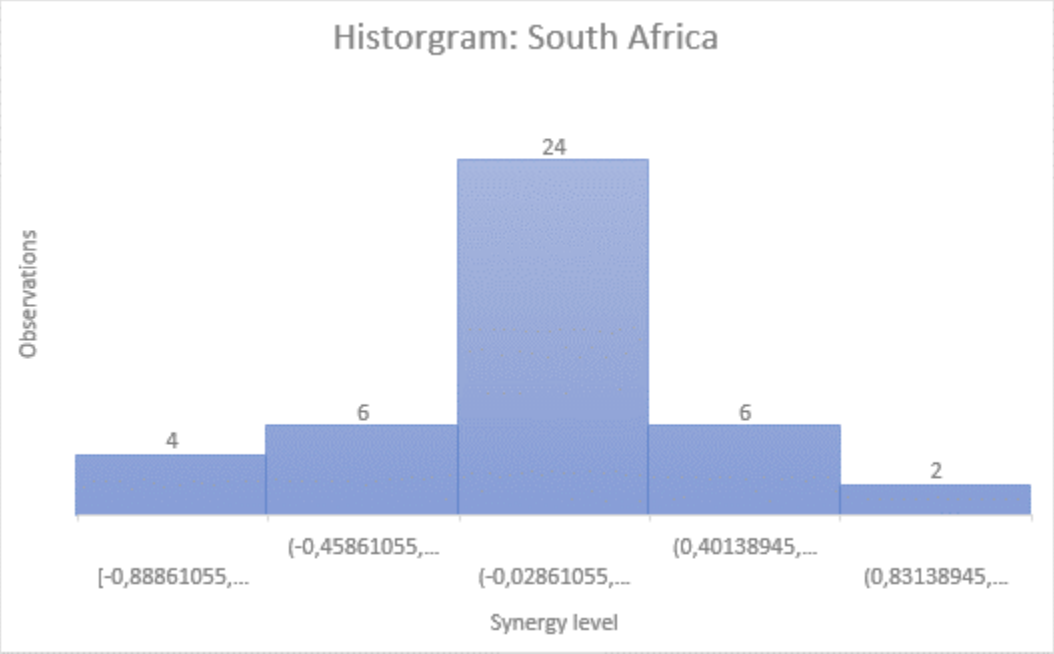

Figure 11. Histogram. South Africa. Synergy level observations level between GDP and electric power consumption (kWh per capita).

Long-run synergy observations of South Africa are having quite a normal statistical distribution.

European Union, United States, Latin America and the Caribbean and Fragile, and countries in fragile and conflict-affected situations

Next, we will move on to reporting on the synergy results of other regions of the world. In Fig. 12 we can observe the synergy level trend curve of the European Union. The long-run trend is turning to negative synergy values. Synergy level is decreasing in the European Union.

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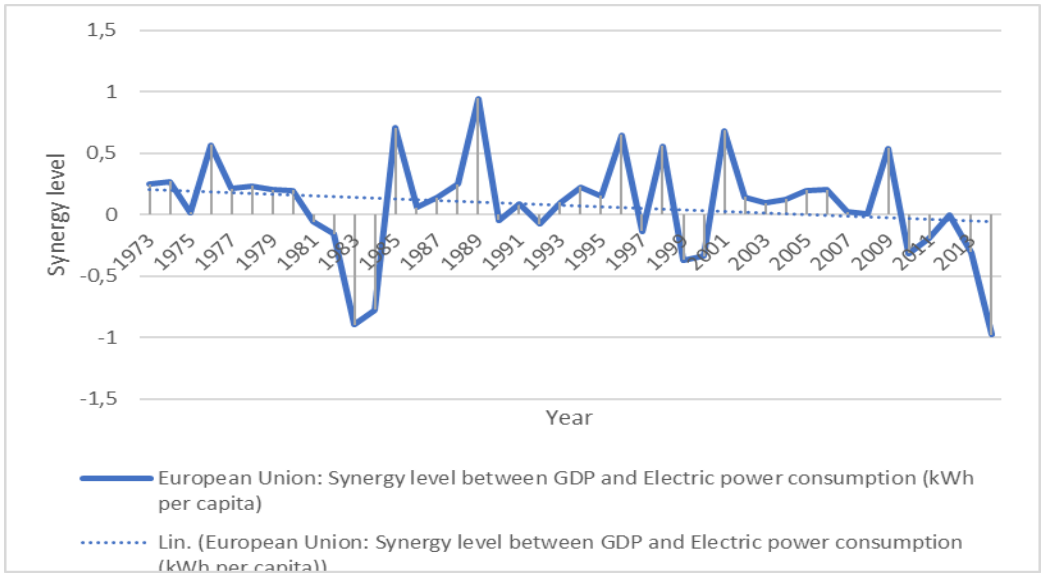

Figure 12: European Union: Synergy level between GDP and electric power consumption (kWh per capita).

The European Union's histogram graph of synergy observations is reported in Figure 13. The distribution is quite normal, perhaps slightly tilted to the right. Synergy observations in the European Union are mostly in between -0,18-+0,22 (22 observations).

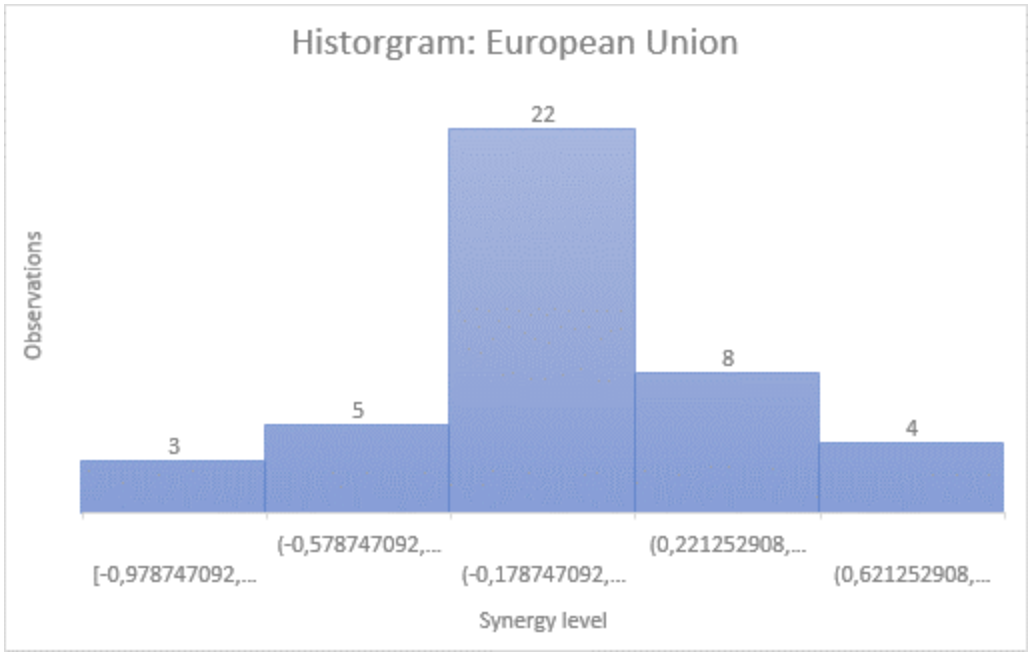

Figure 13: European Union. Synergy level observations level between GDP and electric power consumption (kWh per capita).

In Fig. 14 we can observe a synergy level trend curve of the United States of America (USA). The long-run synergy trend curve is downward-sloping.

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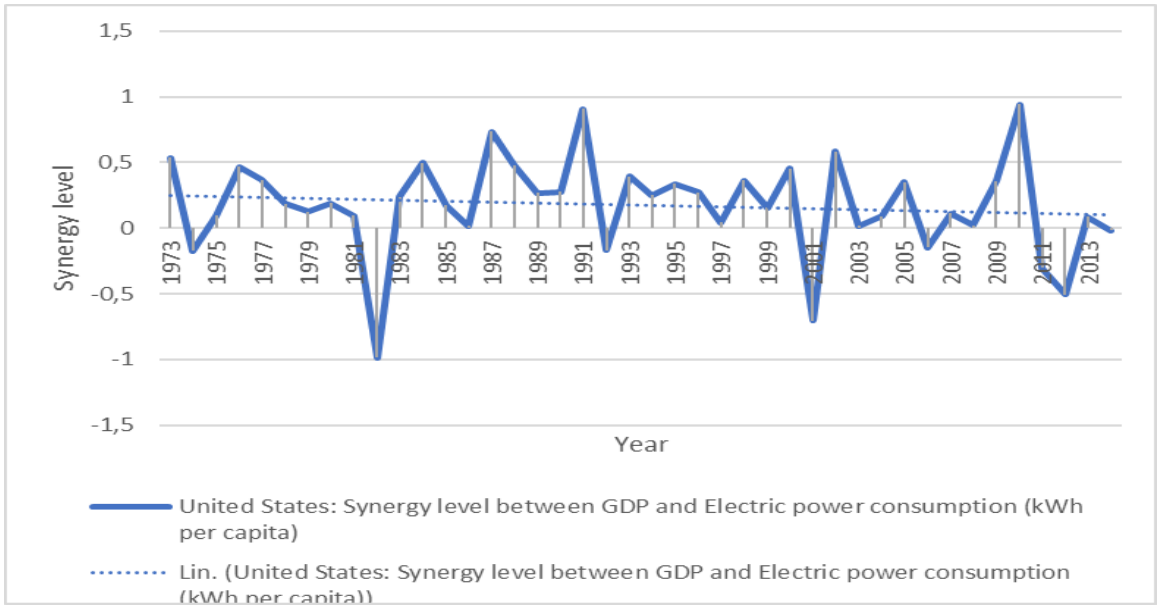

Figure 14: United States: Synergy level between GDP and electric power consumption (kWh per capita).

The histogram graph of synergy observation in the USA is reported in Fig. 15. We see that histogram is negatively skewed in the case of the USA. Most synergy observations are between +0,12 - +0,49 (18 observations).

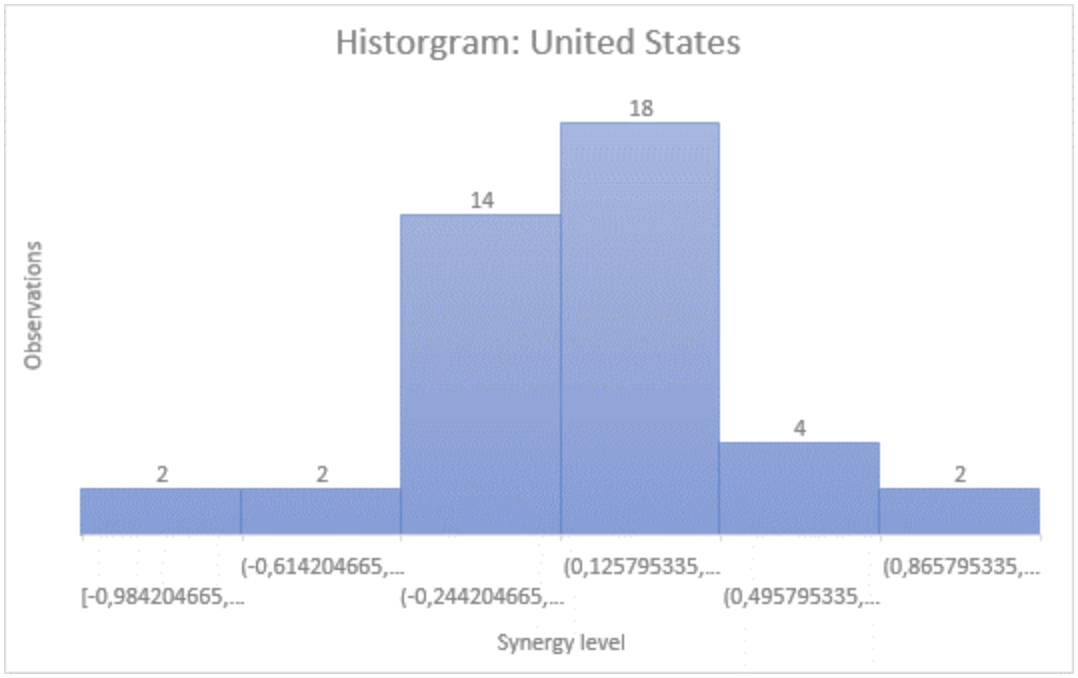

Figure 15: United States: Synergy level observations level between GDP and electric power consumption (kWh per capita).

In Fig. 16 we report synergy trend analysis of the Latin America and the Caribbean. The long-run synergy trend curve is downward-sloping in this global region.

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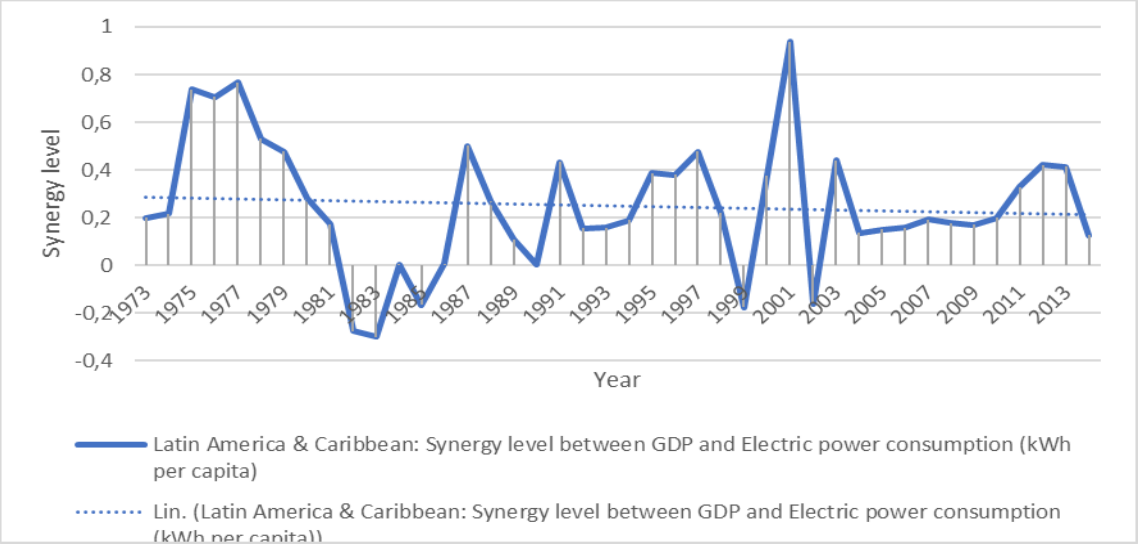

Figure 16: The Latin America and Caribbean region: Synergy level between GDP and electric power consumption (kWh per capita).

The histogram of synergy observation in the Latin America and the Caribbean region is reported in Fig. 17. We see that histogram is positively skewed in the case of the Latin America and Caribbean region. Most synergy observations are between -0,03 - +0,24 (19 observations).

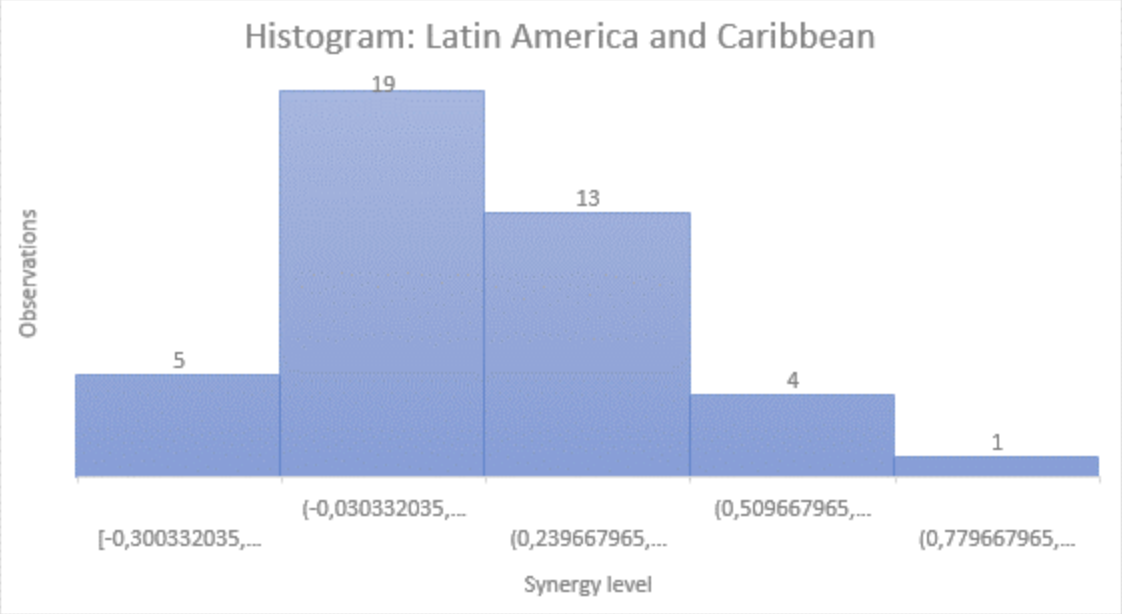

Figure 17: Latin America and Caribbean region: Synergy level observations level between GDP and electric power consumption (kWh per capita).

In Fig. 18 we report the synergy trend level between GDP and electric power consumption (kWh per capita) in the country group of Fragile and conflict-affected countries[1]. In Fig. 18 we can observe that the trend curve is slightly downward-sloping. The average synergy value has been positive and close to zero.

[1] The definition of country group of the Fragile and conflict-affected countries is presented here: FCSList-FY23.pdf (worldbank.org). Conflict-affected countries are Afghanistan, Burkina Faso, Cameroon, the Central African Republic, the Democratic Republic of Congo, Ethiopia, Iraq Mali, Mozambique, Myanmar, Niger, Nigeria, Somalia, South Sudan, the Syrian Arab Republic, Ukraine, the Republic of Yemen. Countries of institutional and social fragility are Burundi, Chad, Comoros, Congo, the Republic of Eritrea, Guinea-Bissau, Haiti, Kosovo, Lebanon, Libya, Marshall Islands, Micronesia, the Federated States of Papua, New Guinea, Solomon Islands, Sudan, Timor-Leste, Tuvalu, Venezuela, RB West Bank, Gaza (territory), and Zimbabwe.

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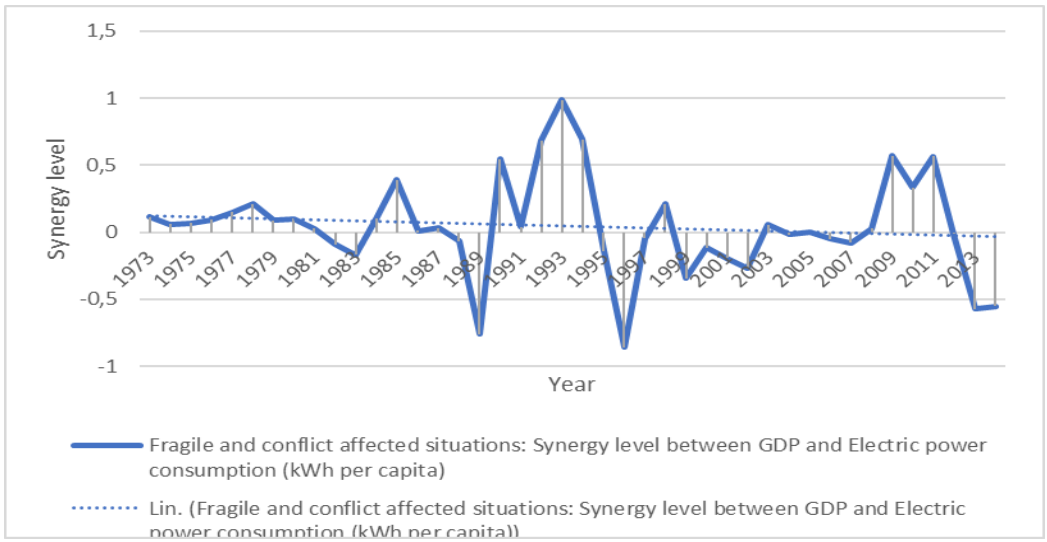

Figure 18: The countries in fragile and conflict-affected situations: Synergy level between GDP and electric power consumption (kWh per capita).

In figure 19 we have reported a histogram of the countries in fragile and conflict-affected situations, in which the statistical distribution of observations is normal. Most of the synergy observations fall between -0,12 - and +0,25 (25 observations). Distribution in this case is very symmetric about the mean.

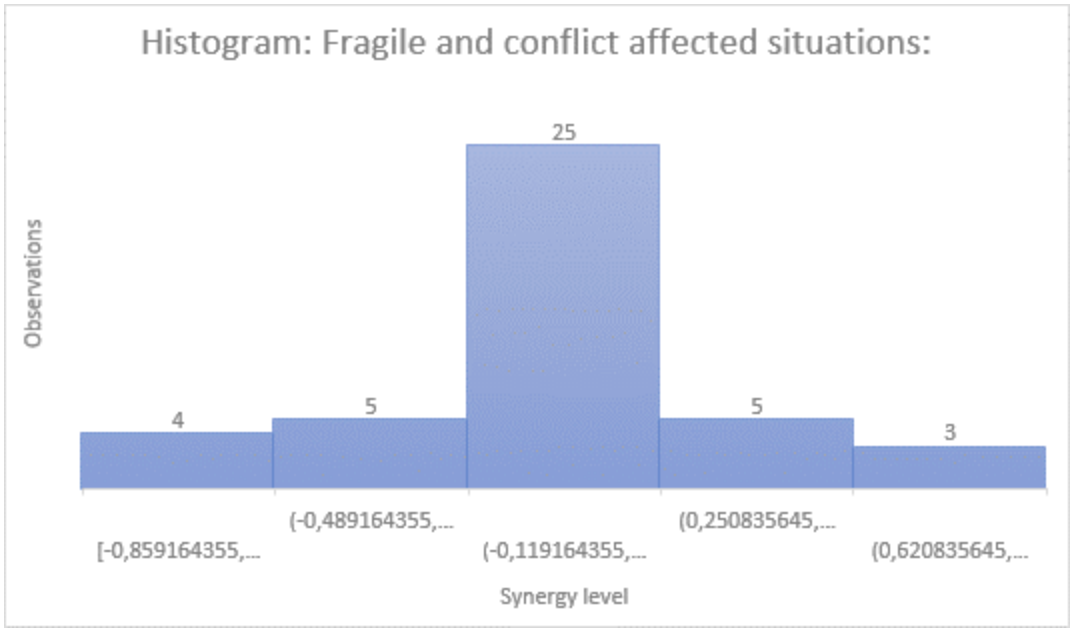

Figure 19: The countries in fragile and conflict-affected situations: Synergy level observations level between GDP and electric power consumption (kWh per capita).

3.3. World

In Fig. 20 we report the synergy trend level between GDP and electric power consumption (kWh per capita) in the World. In Fig. 20 we can see that the trend curve is slightly upward-sloping. The average value of synergy has been positive about + 0,32.

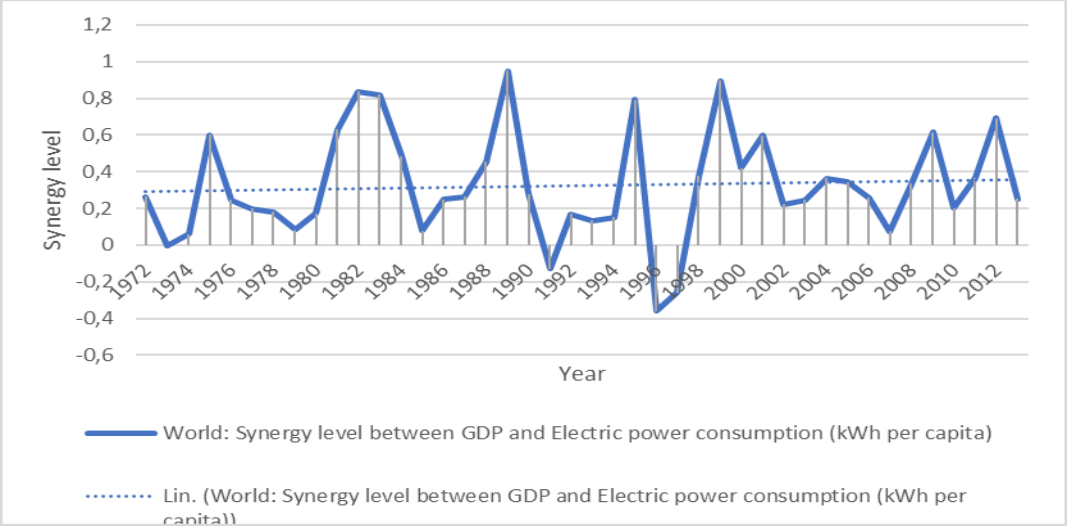

Figure 20: World: Synergy level between GDP and electric power consumption (kWh per capita).

The histogram graph of synergy observation in the world is reported in Fig. 21. We see that histogram is negatively skewed in the World. Most synergy observations are between + 0,24 - +0,54 (16 observations).

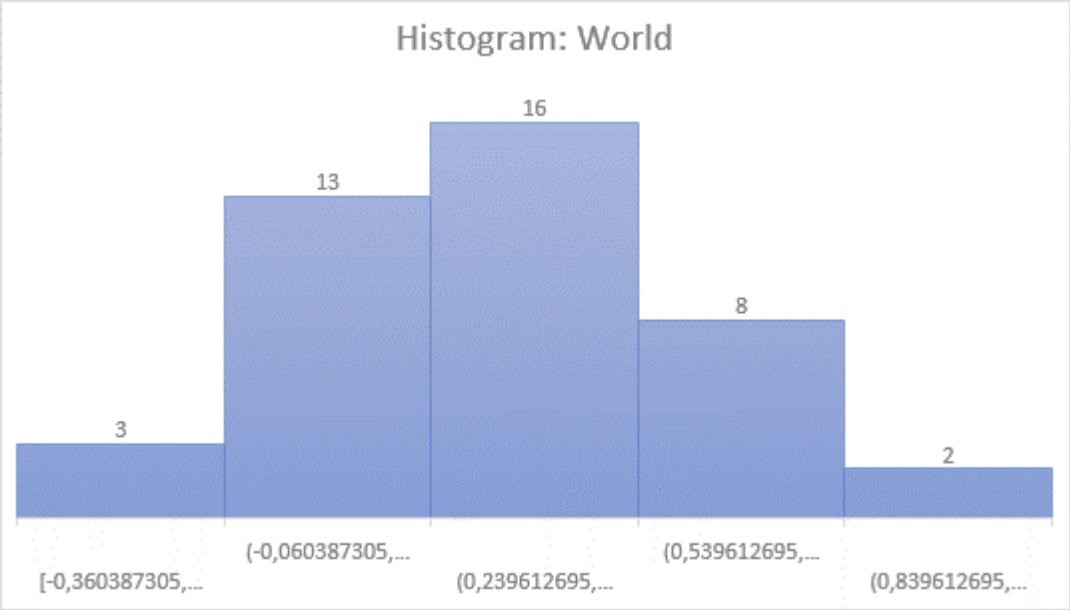

Figure 21. World: Synergy level observations level between GDP and electric consumption (kWh per capita).

Conclusions and summary of results

This empirical study focused on gross domestic growth and electricity consumption in the world and various regions. The results were interesting in many ways. Histogram analyses revealed both negatively skewed and positively skewed distributions, and also some global regional cases had close to normal distributions. Negatively skewed distributions were observed in Brazil, Russian Federation, India, the USA and also in the world synergy analyses. Positively skewed distributions were observed in China, in the Latin America and the Caribbean region, and in the European Union. Normal distributions were observed in South Africa and in the country group of fragile and conflict-affected countries. Other regions had normal or almost normal statistical distributions. In Fig. 22 we report the key statistical indicators of regional synergy levels between GDP and electric consumption (kWh per capita).

From Fig. 22, we can see - according to the statistical analysis of synergy levels, that synergy levels vary considerably in different regions of the world. If decision-makers are not aware of the differences in synergy

levels, they can evaluate decisions incorrectly and biasedly. In this sense, the results presented now are useful for future decisions. The general assumption is that decision-makers have only a rough idea of the direction of this key synergy variable, which is relevant for global climate change policy. Now we have more detailed information on the synergy variable. This more detailed information can be useful to global decision-makers. The reason why the synergy levels are different is partly due to the fact that the development of economies is at a different stage in regions of the world. The reasons for regional synergy differences should be investigated in more detail in further studies.

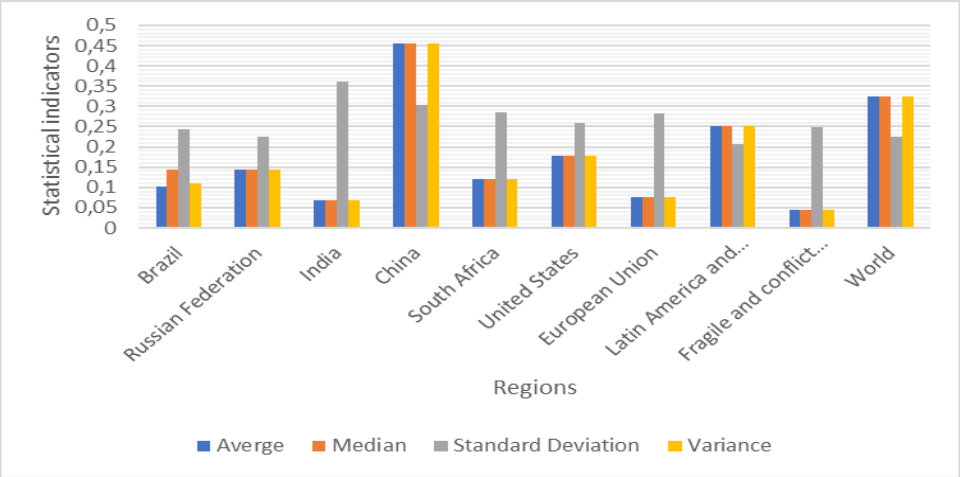

Figure 22: Key statistical indicators of regional synergy levels between GDP and electric consumption (kWh per capita).

ACKNOWLEDGEMENTS: We acknowledge all professional feedback from research fellows of the project Manufacturing 4.0, and from the IRIS projects, which are funded by the Academy of Finland.

FUNDING: The Strategic Research Council (SRC) at the Academy of Finland has partly funded Professor Jari Kaivo-oja, in the Manufacturing 4.0 project (Strategic Research Council, project decision n:o 335989). The authors also want to thank the Academy of Finland for funding the "Cuban energy transformation Integration of Renewable intermittent sources in the power system (IRIS)" project, decision n:o 320229.

CONFLICT OF INTEREST: No conflicts of interest.

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 ISBN: 978-86-87043-85-5

Economic Growth (GDP) and Regional Carbon Dioxide Emissions: Synergy Trend Analysis of Geospatial Regions of the Global Economy: BRICS countries, United States, European Union, Latin America, and Caribbean region, and the Countries in Fragile and Conflict-Affected Situations

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Abstract: (This article includes global synergy trend analyses based on the World Development Indicators published by the Work Bank. The focus of the study is on economic growth (GDP) and CO2 emissions. In order to understand globalization and regional developments, it is good to understand global and regional trends and the interactions between spatial trends. The synergy analysis tool was developed to analyze the synergy between two different trends, but it can be used to analyze simultaneously the synergy between three trends representing the three different dimensions of sustainable development. It is good for decision-makers to be aware - not only of the development of the trends themselves, but they should be aware also of the critical interactions between spatial trends. There may be positive, negative or no synergy between trends. These three different forms of synergy are therefore always possible. That is why this study is important and interesting for a broader audience. The research delivers synergy analysis results of electricity consumption in relation to GDP trends in main regions of the world: (1) the BRICS countries, (2) the United States, (3) the European Union, (4) the Latin America and Caribbean region, and (4) the Countries in Fragile and Conflict-Affected Situations. This analysis is a unique synergy analysis study and all empirical results are first time published in this empirical study. This study provides many results, which are relevant for global energy and climate change policy-makers and especially for the World Bank and for the United Nations.

Keywords: BRICS countries, CO_2 emissions per capita, countries in Fragile and Conflict-Affected Situations electrification, European Union, global GDP, Global trends, synergy analysis, USA, Latin America and Caribbean region, world economy, World Bank Data Base, World Development Indicators.

Introduction

In this empirical study we shall analyze synergy trends between GDP and CO_2 emissions in world regions. The question of CO_2 emissions trends is one of the most critical climate change policy questions. We elaborate this global carbon dioxide phenomenon in relation to economic growth. Our methodology is synergy analysis of these two key trends (economic growth and CO_2 emissions). There various background research articles in this field [1, 2,3,4,5,6,7,8,9]. Key articles linked to global sustainability discussions can be found in [10, 11, 12, 13, 14, 15, 16, 17, 18].

 ISBN: 978-86-87043-85-5

Methodological framework of synergy analysis

When we analyse trends, scenarios or weak signals we typically analyse dynamic social and economic systems. One key aspect of trend analysis is nowadays the interlinkages of trends. This study focuses on the issue of interlinkages of global trends. The data of the study is from the World Bank´s Global Development Indicators data base [19].

The Synergy Index is calculated in the following technical way (Data analysis phases in Steps 5-6) above: We can calculate conventional index number of synergy and average long-run synergy index (see for example [1, 2]). It can be said that there exists synergy between two factors when their combined effect is greater or smaller than the sum of their separate effects. In mathematical form this can be expressed as

$$z = ax + by + cxy + d. \quad (1)$$

where x, y and z are variables and a, b, c and d are coefficients that determine how the output z depends on inputs x and y. In this case we assume a time-invariant system, where the parameters remain constant. If y is 0, the output is determined by x and the coefficients a and d. Coefficients a, b and d determine the impact of the single inputs on the output. The synergy of the inputs x and y is determined by the component cxy, i.e. the co-effect of both the inputs. The idea of synergy indicates choosing variables x and y such that an increase in the value of both variables x and y is desirable and refers to a commonly accepted direction of sustainable development. If we look at a change from A to B in the Figure 1 (from the original state xy0 to x1y1) we can determine the change in the area (Δz) to be

If we look at a change from A to B in the Figure 1 (from the original state x0y0 to x1y1) we can determine the change in the area (Δz) to be

$$\Delta z = a\Delta x + b\Delta y + c\Delta x\Delta y = y0\Delta x + x0\Delta y + \Delta x\Delta y. \quad (2)$$

We can interpret the synergy of the inputs to be determined by the shaded area in Figure 3, which equals ΔxΔy. The synergy can also be negative, as is shown in the Figure 3 where the change in y is negative and ΔxΔy becomes negative. This is a trade-off situation: when one factor increases the other factor decreases. In Figure 3. we have presented 3 basic forms of synergy between two variables.

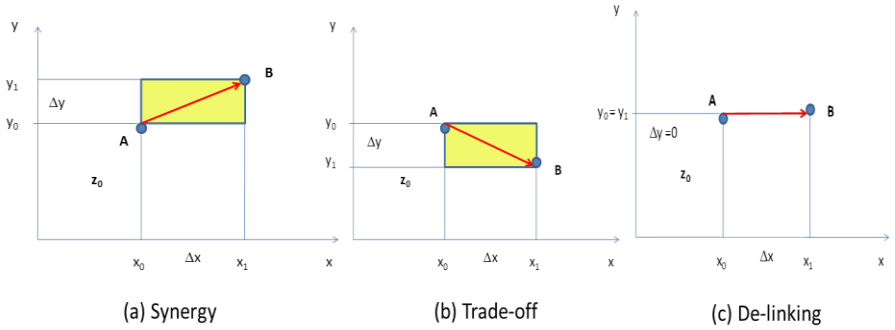

Figure 1: The alternatives of synergy level between two variables, x and y.
The alternatives of synergy level between two variables, x and y.

(1) Maximum synergy can be obtained when relative changes Δx and Δy are equal.

(2) In case the change in y i.e. Δy is larger than changes in x i.e. Δx, the quotient must be inverted to estimate potential synergy ratio.

(3) Therefore, potential synergy/trade-off between two variables can be measured between -1 to +1.

(4) Where negative sign indicates trade-off between two variables.

Thus, synergy level can be positive, negative or there is no synergy at all (de-linking). This idea can be applied in health care and industry field, but maybe in other industrial context contexts, too. Interpretation of the results is straightforward: the closer the calculated synergy factor is to 1 the stronger the synergy between the two (or three)

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variables can potentially be, and the closer the ratio is to −1 the potential for a trade-off is stronger. When the synergy factor is close to 0 there is delinking between the trends. This kind of analysis does not imply that synergy is necessarily good and trade-off is bad, or vice versa. Such interpretation is case specific; to interpret the results in more depth, we need to determine how we would like the trends to involve.

The results of synergy analyses in global regions

BRICS countries

In this section we report the key results of synergy analyses in the BRICS countries. In Fig. 1 we visualize the long-run synergy trend between GDP and CO_2 emissions per cap in Brazil. The synergy trend line is presented in Fig. 2.

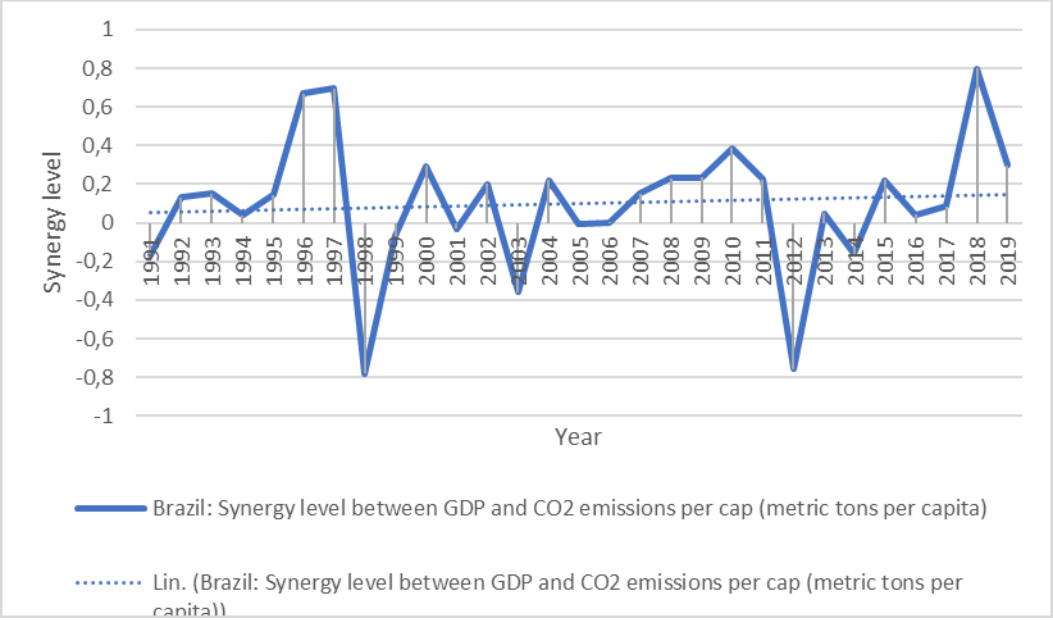

Figure 2: Brazil: Synergy level between GDP and CO_2 emissions per cap (metric tons per capita)

Average synergy trend line is below + 0,2. In Fig 3 we report the histogram graph of synergy level observations level between GDP and CO_2 emissions per cap (metric tons per capita) in Brazil.

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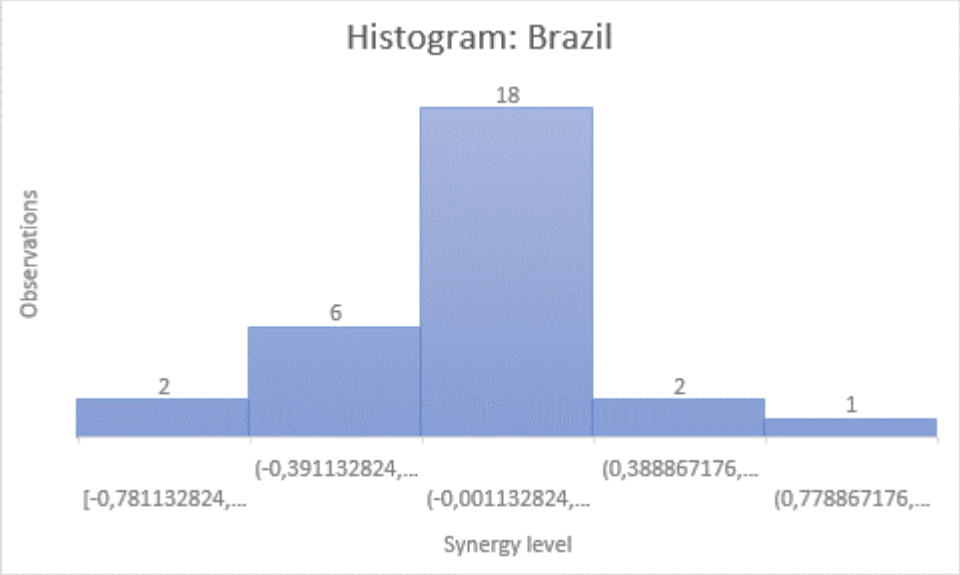

Figure 3: Histogram. Brazil. Synergy level observations level between GDP and CO_2 emissions per cap (metric tons per capita)

In the case of Brazil, synergy observations are mostly in between -0,001-+0,39 (18 observations). We see that this histogram follows almost the conventional shape of normal distribution, however having a slightly negatively skewed distribution.

In Fig. 4 we report the synergy trend line of the Russian Federation. We find that the synergy trend between GDP and CO_2 per capita in Russia is quite stable and even. It is neither bullish nor bearish.

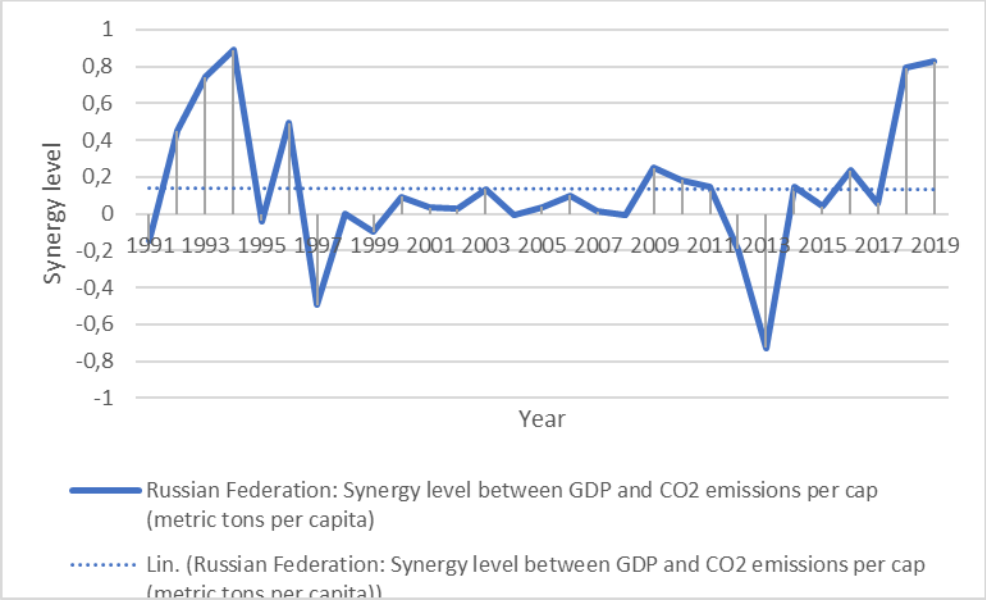

Figure 4: The Russian Federation: Synergy level between GDP and CO_2 emissions per cap (metric tons per capita)

Key finding is that the synergy trend in the Russian case is slightly positive in the long range. In early 1990s it was very positive, but in the mid of 1990s, it started to turn to a very low negative level. In years 2011 and 2013 is reached negative synergy levels. Again, in 2019 positive synergies were observed.

In Fig 5, we report a histogram figure of the Russian Federation. Figure 5 reports a right-skewed distribution. There is some positive synergy between analyzed trend variables (GDP add CO_2 per capita), but only on a very low level.

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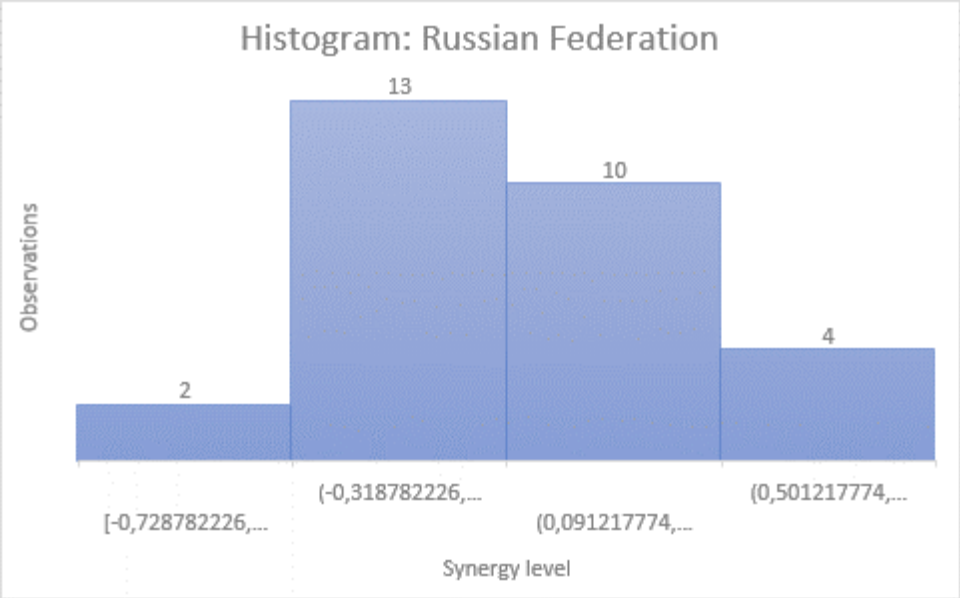

Figure 5: Histogram. The Russian Federation. Synergy level observations level between GDP and CO_2 emissions per cap (metric tons per capita)

In Fig. 6 we report the synergy level between GDP and CO_2 emissions per cap (metric tons per capita) in India. The synergy trend is slightly upward-sloping in this special case of the Russian Federation.

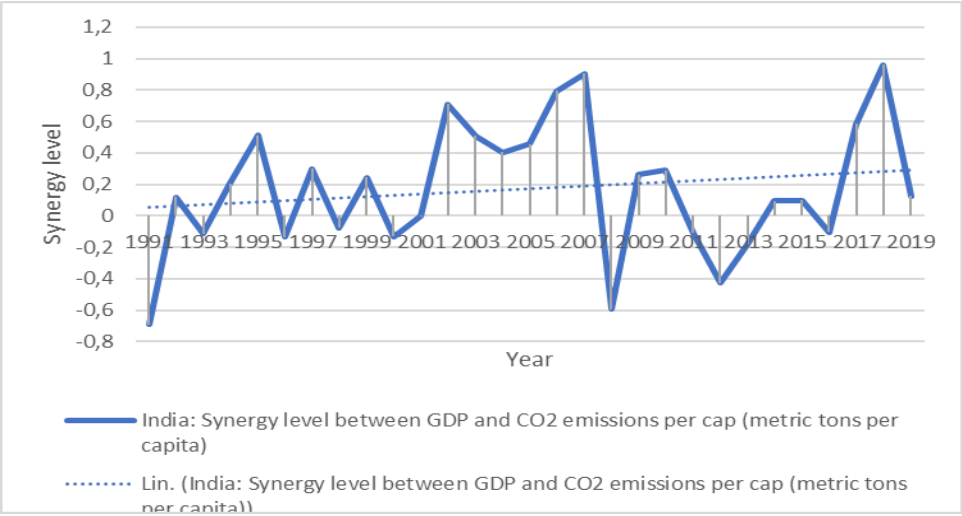

Figure 6: India: Synergy level between GDP and CO_2 emissions per cap (metric tons per capita)

In Fig. 7, we report a histogram of synergy observations in the analysis of India. We can observe that the distribution, in this case, is not normal and positive skewness can be observed. Most observations are between -0,22 - + 0,25 (14 observations).

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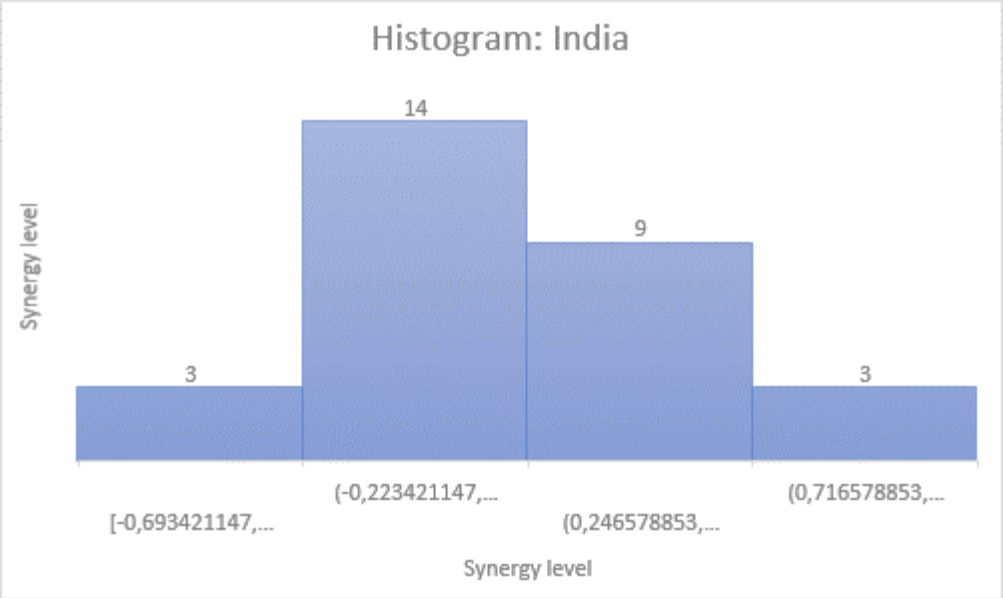

Figure 7: Histogram. India. Synergy level observations level between GDP and CO_2 emissions per cap (metric tons per capita)

In Fig. 8 we report the synergy level between GDP and CO_2 emissions per cap (metric tons per capita) in China. In this case, we see that the synergy trend is clearly downward-sloping in China.

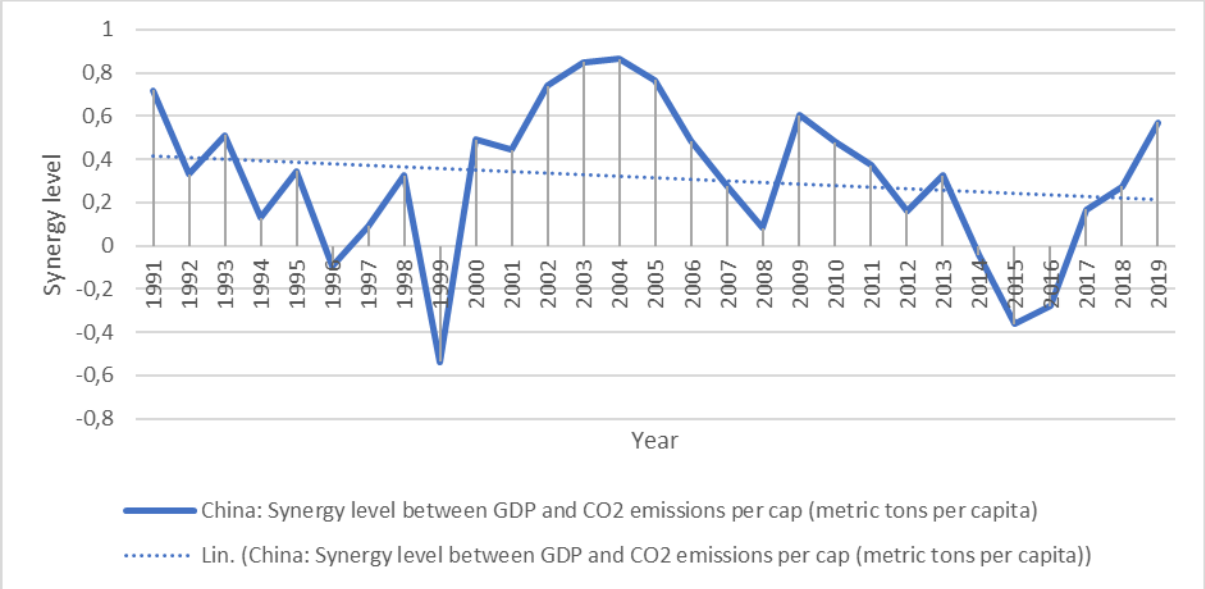

Figure 8: China: Synergy level between GDP and CO_2 emissions per cap (metric tons per capita)

The histogram of synergy observations in China is reported in Fig. 9. We see that histogram is negatively skewed in the case of China. Most synergy observations are between +0,26 - +0,66 (14 observations).

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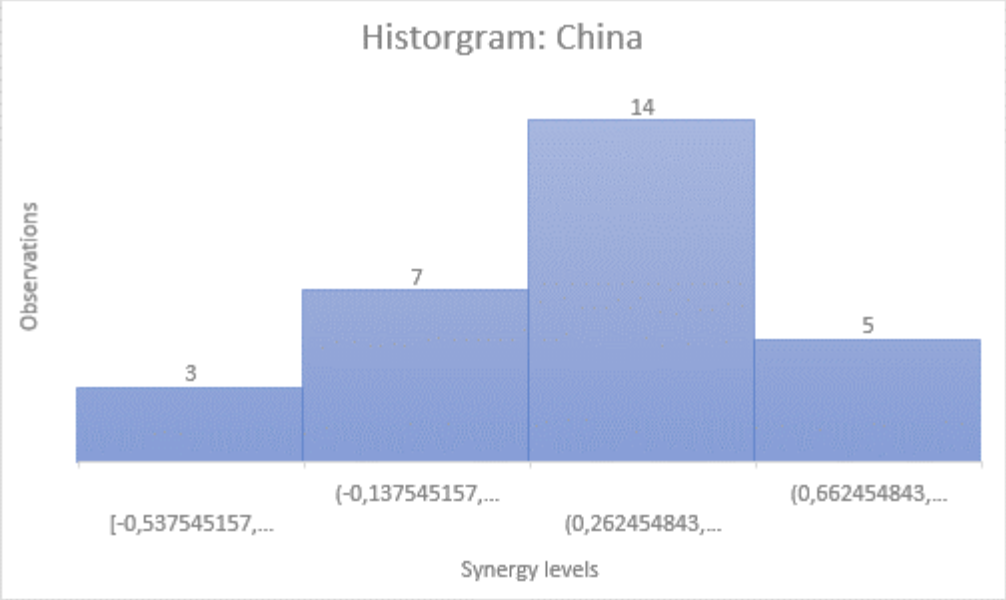

Figure 9: Histogram. China. Synergy level observations level between GDP and CO_2 emissions per cap (metric tons per capita)

Figure 10 shows the trend curve of synergy development in South Africa. It is a stable linear synergy trend curve, but average synergy level is very small and negative value.

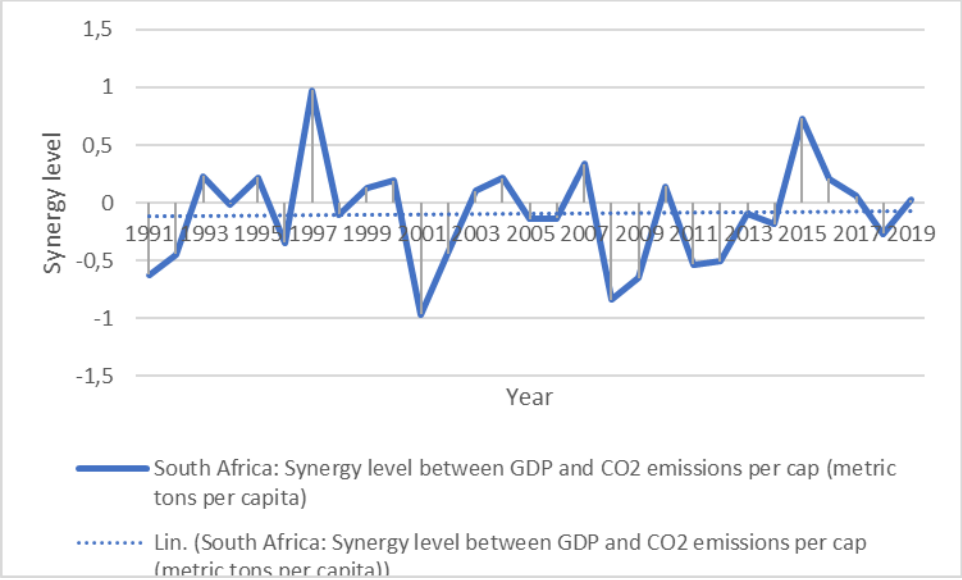

Figure 10: South Africa: Synergy level between GDP and CO_2 emissions per cap (metric tons per capita)

In Fig. 11 we have reported a histogram of South Africa, in which the distribution of observations is quite normal, but slightly negatively skewed. Most of the synergy observations fall between -0,46 - and +0,03 (11 observations).

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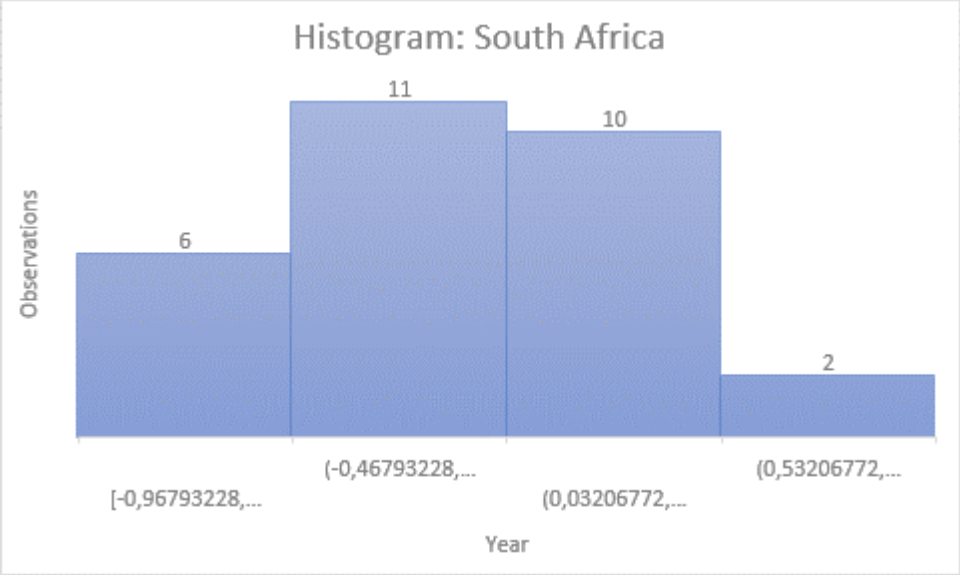

Figure 11: Histogram. South Africa. Synergy level observations level between GDP and CO_2 emissions per cap (metric tons per capita)

European Union, United States, Latin America and the Caribbean and Fragile and Countries in fragile and conflict-affected situations

Next, we will move on to reporting on the synergy results of other regions of the world. In Fig. 12 we can observe the synergy level trend curve of the European Union. The long-run synergy trend is turning to negative synergy values.

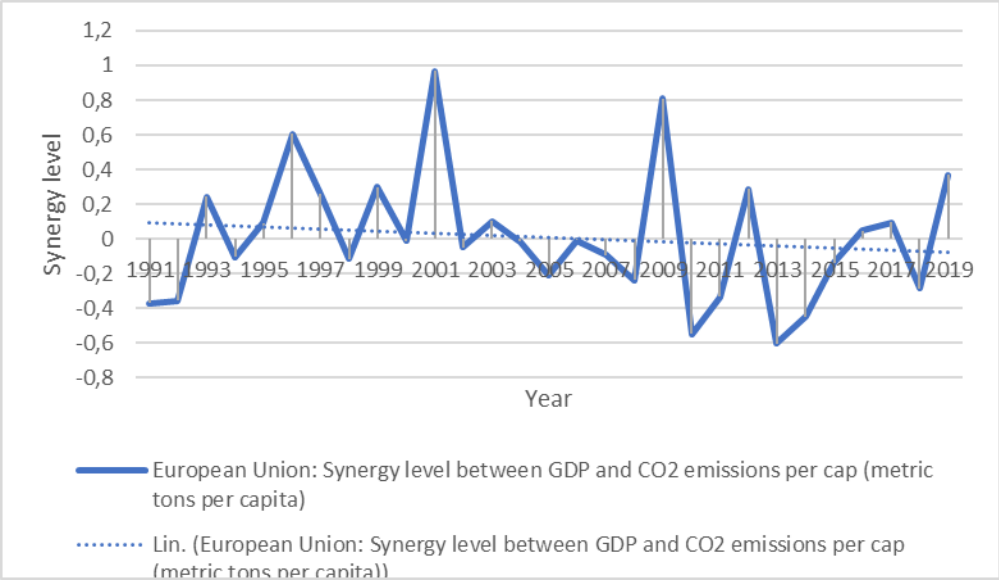

Figure 12: European Union: Synergy level between GDP and CO_2 emissions per cap (metric tons per capita)

The European Union's histogram graph of synergy findings is reported in Figure 12. The distribution is quite normal, however, tilted to the right. Most of the synergy observations fall between -0,17 - and +0,25 (13 observations).

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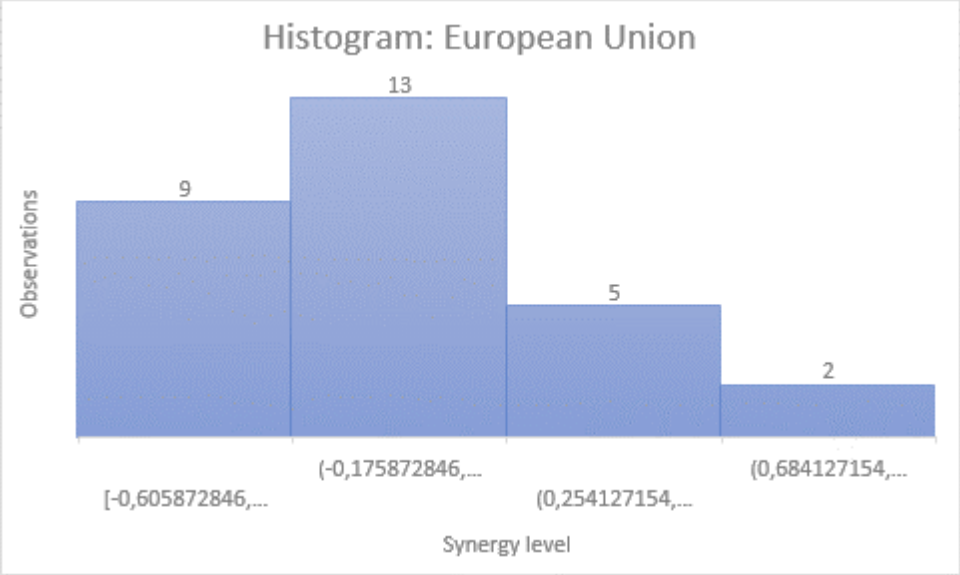

Figure 13: European Union. Synergy level observations level between GDP and CO_2 emissions per cap (metric tons per capita)

In Fig. 14 we can observe the synergy level trend curve of the United States of America. The long-run synergy trend curve is strongly downward-sloping. Synergy levels are decreasing clearly.

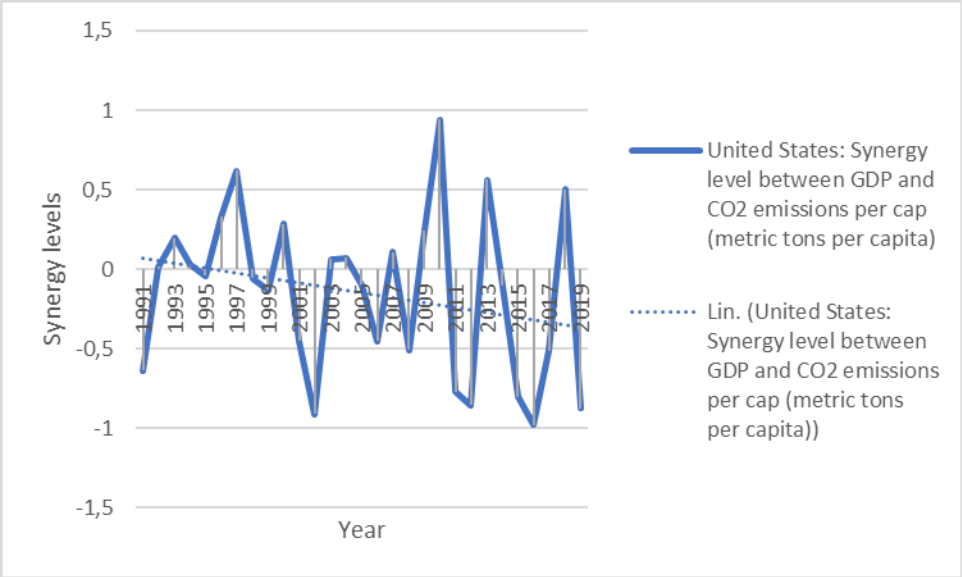

Figure 14. United States: Synergy level between GDP and CO_2 emissions per cap (metric tons per capita)

The histogram of synergy observation in the USA is reported in Fig. 14. We see that histogram is strongly negatively skewed in the case of the USA. Most synergy observations are between -0,98- +0,20 (22 observations).

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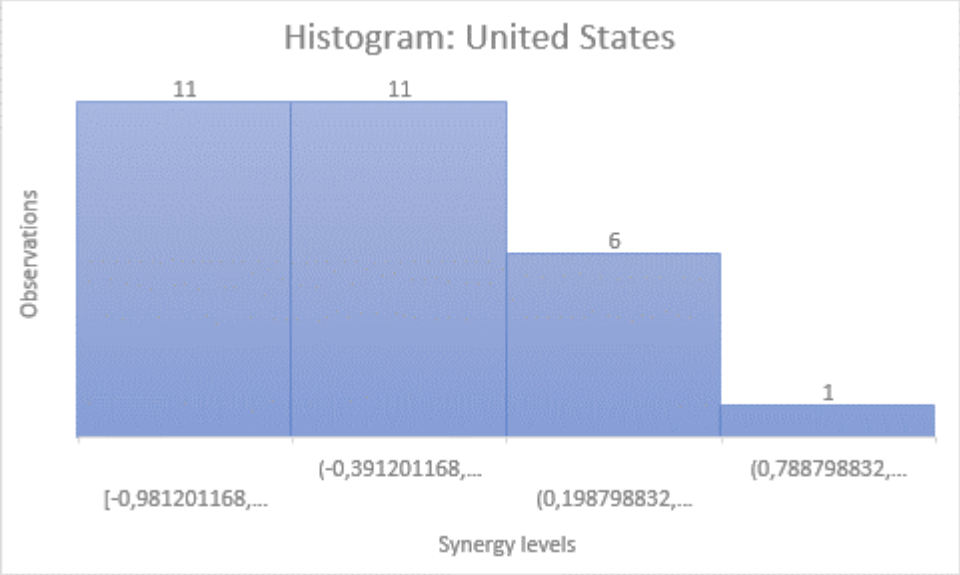

Figure 15: United States: Synergy level observations level between GDP and CO_2 emissions per cap (metric tons per capita)

In Fig. 16 we report a synergy trend analysis of the region of Latin America and the Caribbean. The long-run synergy trend curve is clearly upward-sloping in this case.

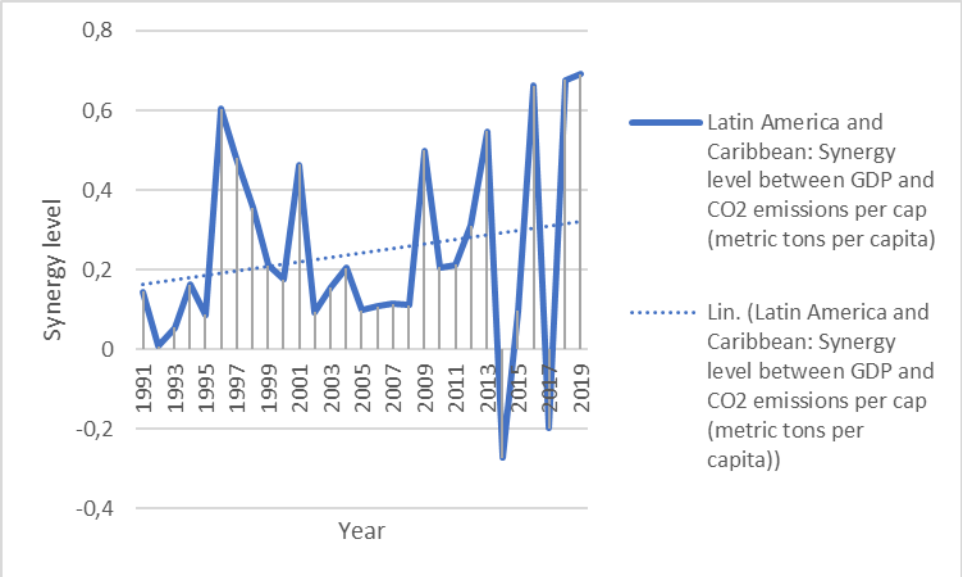

Figure 16: Latin America and the Caribbean region: Synergy level between GDP and CO_2 emissions per cap (metric tons per capita)

The histogram of synergy observation in the region of Latin America and Caribbean region is reported in Fig. 17. We see that histogram is positively skewed in the case of the Latin America and Caribbean region. Most synergy observations are between 0 - +0,28 (17 observations).

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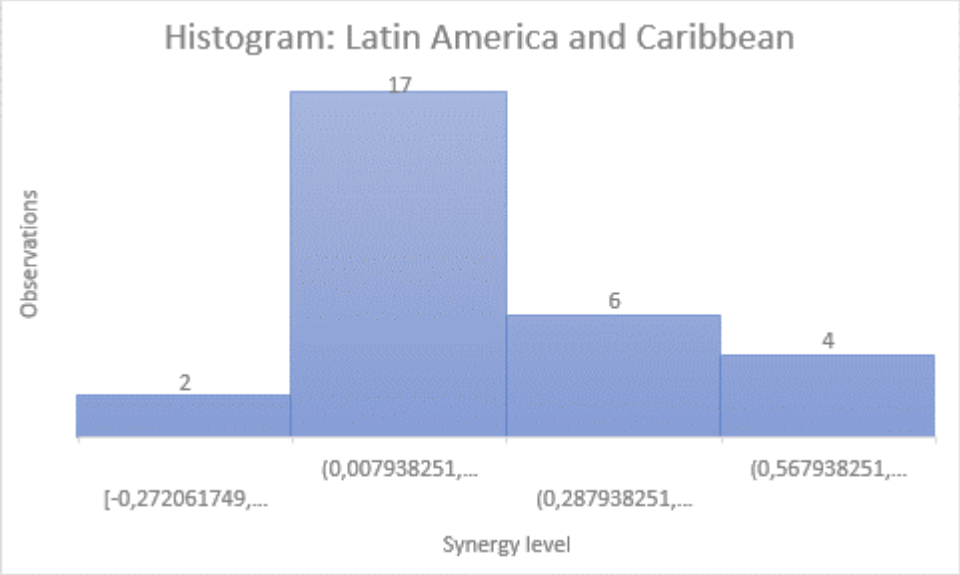

Figure 17: Latin America and Caribbean region: Synergy level observations level between GDP and CO_2 emissions per cap (metric tons per capita)

In Fig. 18 we report the synergy trend level between GDP and CO_2 emissions per capita in the country group of fragile and conflict-affected situations defined by the World Bank.[1] In Fig. 18, we can see that the trend curve is slightly downward-sloping. The average synergy level has been positive and close to zero. Variations in the level of synergy have been big.

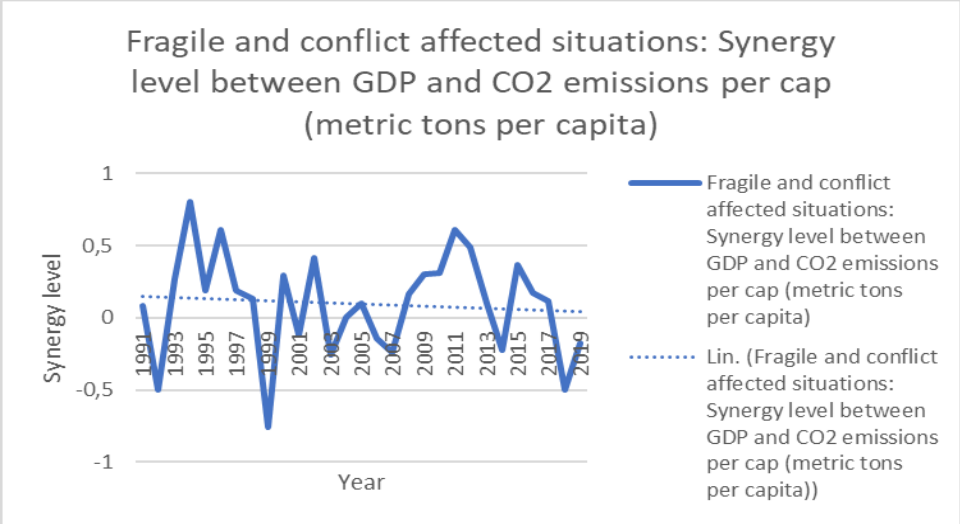

Figure 18: Countries in fragile and conflict-affected situations: Synergy level between GDP and CO_2 emissions per cap (metric tons per capita)

[1] The definition of a country group of Fragile and conflict-affected countries is presented here: FCSList-FY23.pdf (worldbank.org). Conflict-affected countries are Afghanistan, Burkina Faso, Cameroon, the Central African Republic, the Democratic Republic of Congo, Ethiopia, Iraq Mali, Mozambique, Myanmar, Niger, Nigeria, Somalia, South Sudan, the Syrian Arab Republic, Ukraine, the Republic of Yemen. Countries of institutional and social fragility are Burundi, Chad, Comoros, Congo, the Republic of Eritrea, Guinea-Bissau, Haiti, Kosovo, Lebanon, Libya, Marshall Islands, Micronesia, the Federated States of Papua, New Guinea, Solomon Islands, Sudan, Timor-Leste, Tuvalu, Venezuela, RB West Bank, and Gaza (territory), and Zimbabwe.

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In figure 19 we have reported a histogram of the countries in fragile and conflict-affected situations, in which the distribution of observations is negatively skewed. Most of the synergy observations fall between +0,04 - and +0,44 (15 observations).

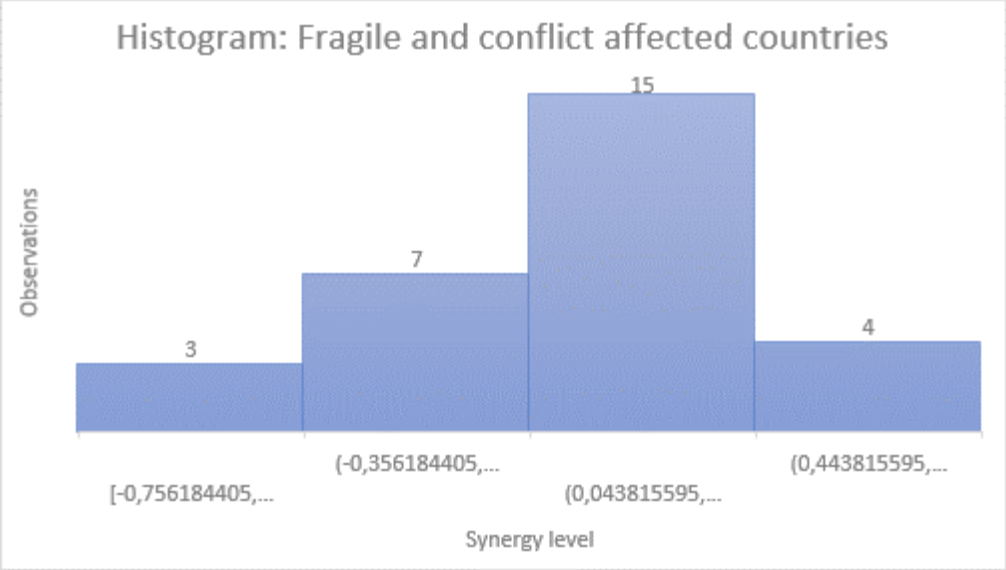

Figure 19: Countries in fragile and conflict-affected situations: Synergy level observations level between GDP and CO_2 emissions per cap (metric tons per capita)

World

In Fig. 20 we report the synergy trend level between GDP and CO_2 emissions per capita in the World. In Fig. 20 we can see that the trend curve is slightly upward-sloping. The average synergy level has been negative, from 1991 to 2002, but later, in 2005-2019, it has been positive. Again, variations in synergy levels have been big. The maximum level of synergy level has been about 0,5, and the minimum level has been -0,8.

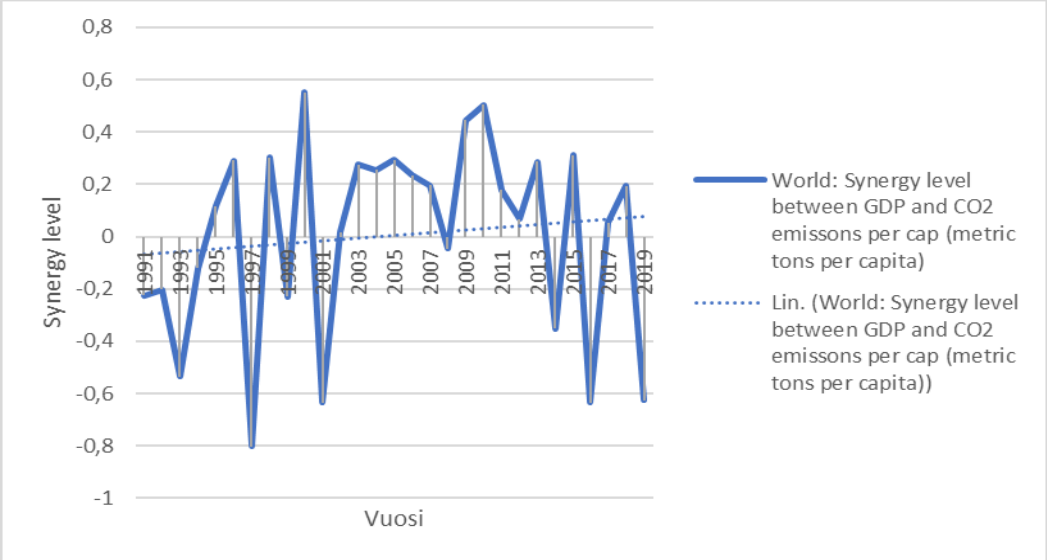

Figure 20: World: Synergy level between GDP and CO_2 emissions per cap (metric tons per capita)

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The histogram of synergy observations in the World is reported in Fig. 21. We see that the histogram graph is negatively skewed in the World, which is a very important finding as such. Most synergy observations are between + 0,05 - +0,49 (14 observations).

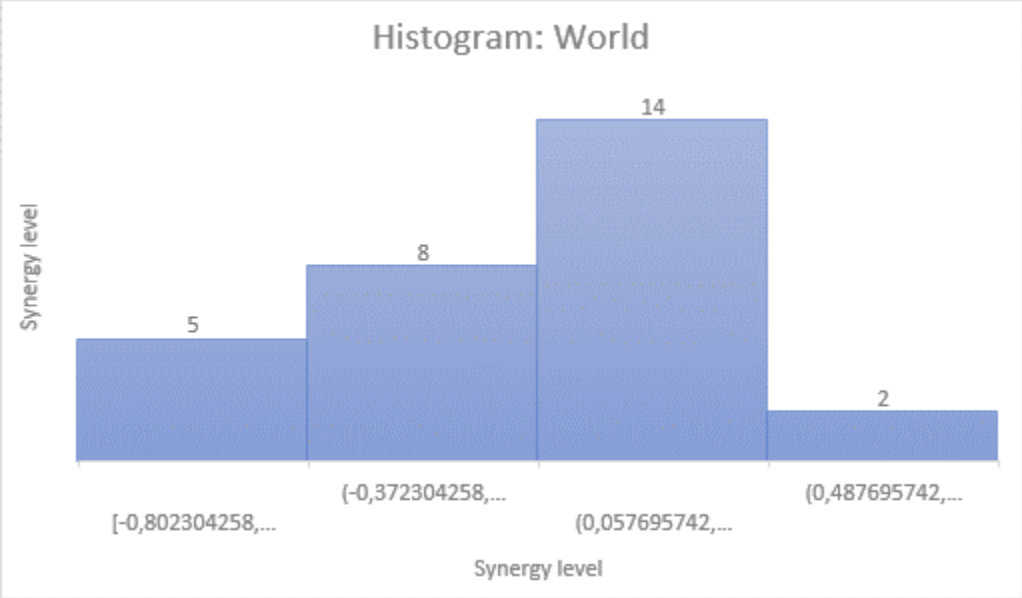

Figure 21: World: Synergy level observations level between GDP and CO_2 emissions per cap (metric tons per capita).

Conclusions and summary of results

This empirical study was focused on regional CO_2 emissions per capita and economic growth in the world and in various regions of the world. The results we interesting in many ways. Histogram analyses revealed both negatively skewed and positively skewed distributions. Negatively skewed distributions were observed in the world, in fragile and conflict-affected countries, in Latin America and the Caribbean region, in China, in Brazil, in the USA, and also in the European Union. Positively skewed distribution was observed in South Africa, India and in the Russian Federation. Normal distribution was not observed in the spatial analysis of this synergy study, which is a very interesting finding, as such. In Fig 22, we report key statistical indicators of regional synergy levels between GDP and CO_2 emissions per cap (metric tons per capita).

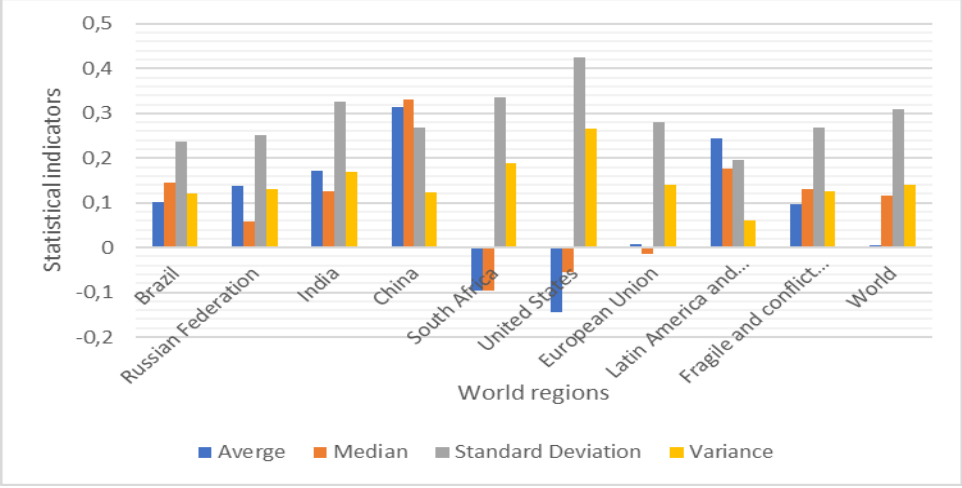

Figure 22: Key statistical indicators of regional synergy levels between GDP and CO_2 emissions per capita

From Fig. 22 we can see that synergy levels vary considerably in different regions of the world. If decision-makers are not aware of the difference in synergy levels, they can evaluate political and economic decisions incorrectly and

biasedly. In this sense, the results presented now in this study, are useful and policy-relevant for future decisions on global climate change and energy policy. The reason why the synergy levels are different is partly due to the fact that the developments of economies are at different stages in different global regions of the world. Obviously, the reasons for regional synergy differences should be investigated in more detail in further studies.

ACKNOWLEDGEMENTS: We acknowledge all professional feedback from research fellows of the project Manufacturing 4.0, and from the IRIS projects, which are funded by the Academy of Finland.

FUNDING: The Strategic Research Council (SRC) at the Academy of Finland has partly funded Professor Jari Kaivo-oja, in the Manufacturing 4.0 project (Strategic Research Council, project decision n:o 335989). The authors also want to thank the Academy of Finland for funding the "Cuban energy transformation Integration of Renewable intermittent sources in the power system (IRIS)" project, decision n:o 320229.

CONFLICT OF INTEREST: No conflicts of interest.

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 ISBN: 978-86-87043-85-5

Global Trends and World Development Indicators: Synergy Trends of Key Global Trends: Global Gross Domestic Growth in Relation to Global CO_2 Emissions, Global Electric Power Consumption, Global Population, and Global Schooling Index Data

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Abstract: This article includes global synergy trend analyses based on the world development indicators published by the work bank. in order to understand globalization phenomena, it is good to understand global trends and the interactions between global trends. The empirical study is based on the World Bank global data sets of world development indicators. The synergy analysis method and tool were developed to analyze the synergy between two different trends, but it can be used to analyze simultaneously the synergy between three trends representing the three different dimensions of sustainable development. It is good for decision-makers to be aware - not only of the development of the trends themselves, but decision-makers should be aware also of the interactions between global trends. there may be positive, negative, or no synergy between trends. These three different forms of synergy are therefore always possible. that is why this study is important and interesting. The empirical research delivers synergy analysis results of global trends in relation to global GDP. The critical global synergy analyses are linked to (1) global co_2 emission, trend, (2) a trend in global electric power consumption, (3) global population trends, (4) population density trends, and (5) two critical global schooling index numbers (global primary completion rate (GPCR) and gender parity index, GPI) trends. This analysis is a unique synergy analysis study and all reported results are for the first time published in this empirical synergy study. This study provides many new results about synergies, which are relevant for global policy-makers and especially for the World Bank and for the United Nations.

KEYWORDS: Global trends, synergy analysis, global GDP, global population, global CO_2 emissions, global electric consumption and global school index data, World Bank data base.

Introduction

This empirical study presents the interaction of key global trends based on synergy analyses. It is good for decision-makers to be aware - not only of the development of the trends themselves, but they should be aware also of the interactions between the trends. That is why this study is important and interesting. In this study, we present empirical findings in terms of interactions based on synergy analyses. The results presented in this study show interactions, from 1972 until 2020. This is a statistical assessment of about two dozen years, which can be considered a long enough period to look at the trends of the global economy.

There may be positive, negative or no synergy between trends. These three different forms of synergy are therefore always possible. The form and direction of synergy trends can change over time and if decision-makers are not aware of the changes in synergy, they can already make the wrong decisions due to this lack of relevant information. For this logical reason alone, this empirical research is important for the global community.

In recent years, it has been noticed that synergy analysis is a very useful methodological approach to studying sustainability challenges and processes [1, 2, 3, 4, 5, 6, 7, 8,]. In the study of sustainable development, a very central issue is the temporal development of economic variables, social development variables, and environmental variables [9, 10, 11, 12, 13, 14, 15, 16, 17, 18]. For example, taking demographic trends into account as part of the assessment of sustainable development challenges is a very broad research theme [19]. The same consideration applies to the progress of climate change and the associated social, ecological, and economic trends and processes. [20]. It is good to note that synergy analyses are always related to knowledge management and decision-making [21]. Several studies have found that sustainability indicators are not always put to good use or are simply not used [22]. Decision-makers should be aware of the synergy between key variables, be it positive or negative synergies [23]. For example, the application and assessment of the well-known nexus model cannot be done properly without synergy analyses [24, 25, 26, 27]. Synergy analyses should be used more integrated into sustainable development policies.

The methodological framework of synergy analysis

When we analyse trends, scenarios, or weak signals we typically analyze dynamic social and economic systems. One key aspect of trend analysis is nowadays the interlinkages of trends. This study focuses on the issue of interlinkages of global trends. The data of the study is from the World Bank´s Global Development Indicators database [28]

The Synergy Index is calculated in the following technical way (Data analysis phases in Steps 5-6) above: We can calculate the conventional index number of synergy and average long-run synergy index (see for example [1, 2]). It can be said that there exists a synergy between two factors when their combined effect is greater or smaller than the sum of their separate effects. In mathematical form, this can be expressed as

$$z = ax + by + cxy + d. \quad (1)$$

where x, y and z are variables and a, b, c and d are coefficients that determine how the output z depends on inputs x and y. In this case, we assume a time-invariant system, where the parameters remain constant. If y is 0, the output is determined by x and the coefficients a and d. Coefficients a, b, and d determine the impact of the single inputs on the output. The synergy of the inputs x and y is determined by the component cxy, i.e. the co-effect of both inputs. The idea of synergy indicates choosing variables x and y such that an increase in the value of both variables x and y is desirable and refers to a commonly accepted direction of sustainable development. If we look at a change from A to B in the Fig. 1, (from the original state xy0 to x1y1) we can determine the change in the area (Δz) to be

If we look at a change from A to B in Fig. 1 (from the original state x0y0 to x1y1) we can determine the change in the area (Δz) to be

$$\Delta z = a\Delta x + b\Delta y + c\Delta x\Delta y = y0\Delta x + x0\Delta y + \Delta x\Delta y. \quad (2)$$

We can interpret the synergy of the inputs to be determined by the shaded area in Figure 3, which equals $\Delta x\Delta y$. The synergy can also be negative, as is shown in Fig. 1 where the change in y is negative, and $\Delta x\Delta y$ becomes negative. This is a trade-off situation: when one factor increases the other factor decreases. In Figure 3. we have presented 3 basic forms of synergy between two variables.

 ISBN: 978-86-87043-85-5

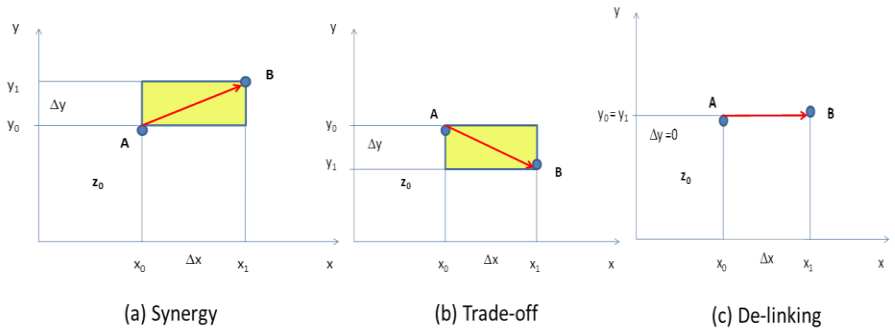

Figure 1. The alternatives of synergy level between two variables, x and y.
The alternatives of synergy level between two variables, x and y.

(1) Maximum synergy can be obtained when relative changes Δx and Δy are equal.

(2) In case the change in y i.e. Δy is larger than changes in x i.e. Δx, the quotient must be inverted to estimate the potential synergy ratio.

(3) Therefore, potential synergy/trade-off between two variables can be measured between -1 to +1.

(4) Where the negative sign indicates a trade-off between two variables.

Thus, the synergy level can be positive, negative or there is no synergy at all (de-linking). This idea can be applied in health care and industry field, but maybe in other industrial context contexts, too. Interpretation of the results is straightforward: the closer the calculated synergy factor is to 1 the stronger the synergy between the two (or three) variables can potentially be, and the closer the ratio is to −1 the potential for a trade-off is stronger. When the synergy factor is close to 0 there is delinking between the trends. This kind of analysis does not imply that synergy is necessarily good and the trade-off is bad, or vice versa. Such interpretation is case specific; to interpret the results in more depth, we need to determine how we would like the trends to involve.

The results of synergy analyses

In this chapter, we present the key findings of global and regional synergy analyses. We report very succinctly and briefly, because the space for presenting the results is limited

The synergy between GDP capita and electricity consumption per capita, and CO_2 emissions

Figure 2 shows a synergy analysis between variables GDP per capita and global electricity consumption.

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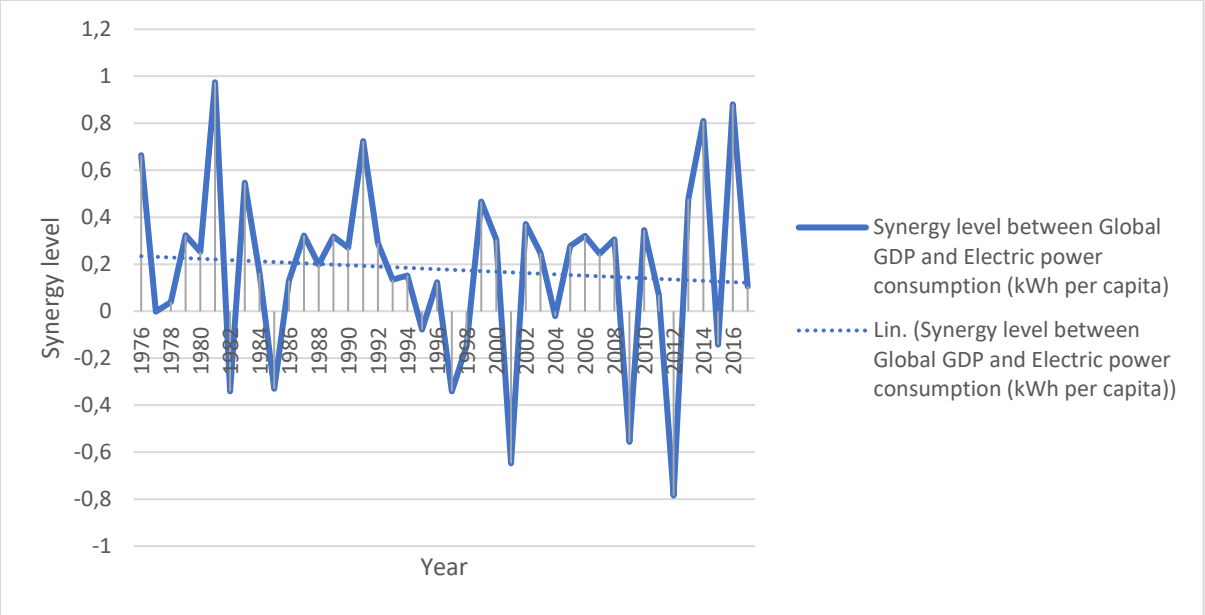

Figure 2: Synergy level between global GDP and global electricity consumption per capita.

The key result based on Figure 2 is that the level of synergy between the two variables has been slightly decreasing over the period of the years 1976-2017, under review.

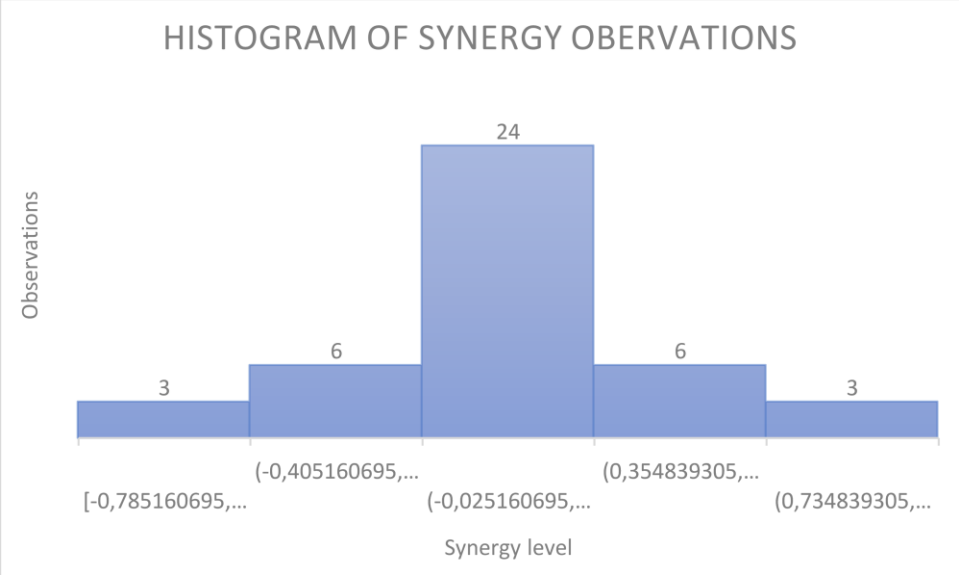

Figure 3. Histogram of synergy observations between global GDP and global electricity consumption per capita.

Figure 3 shows the histogram of the findings of synergy analysis (global GDP and global electricity consumption). It indicates that the observations are normally distributed. Most of the synergy findings fall between values -0,025-+0,35 (24 observations).

In Figure 4, we have reported the results of the synergy development between GDP and global CO_2 emissions.

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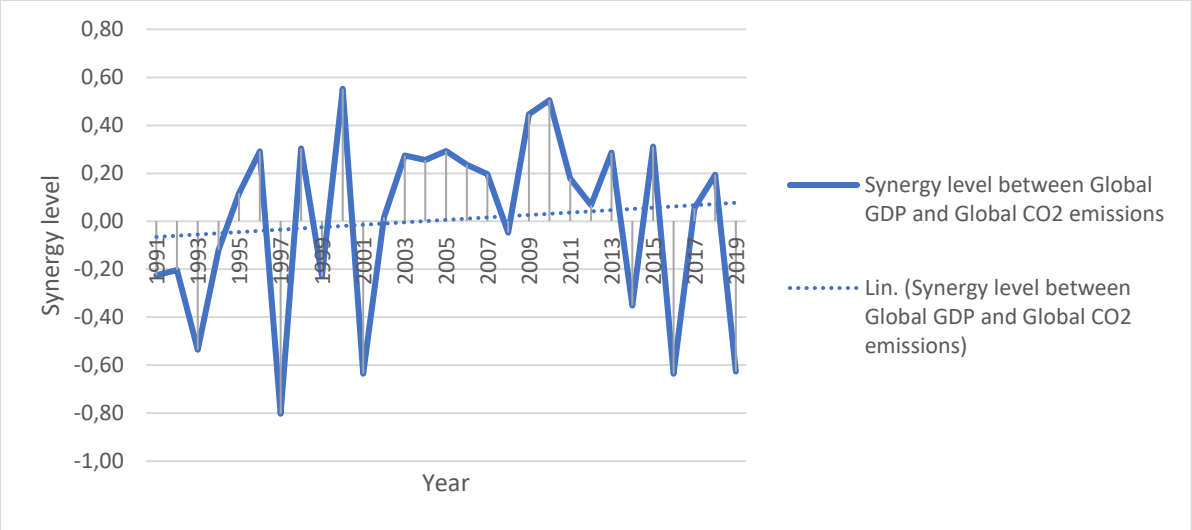

Figure 4: Synergy level between global GDP and global CO_2 emission.

In Figure 4, we see a slight upward trend in synergy. In Figure 4, it is interesting to see that after the year 2011, the synergy trend has clearly turned negative. This is a significant finding in terms of global climate policy. In Figure 5, we have reported the history of the findings of synergy analysis of these two key climate policy variables. It indicates that the observations are not normally distributed. We see that histogram is negatively skewed in this case.

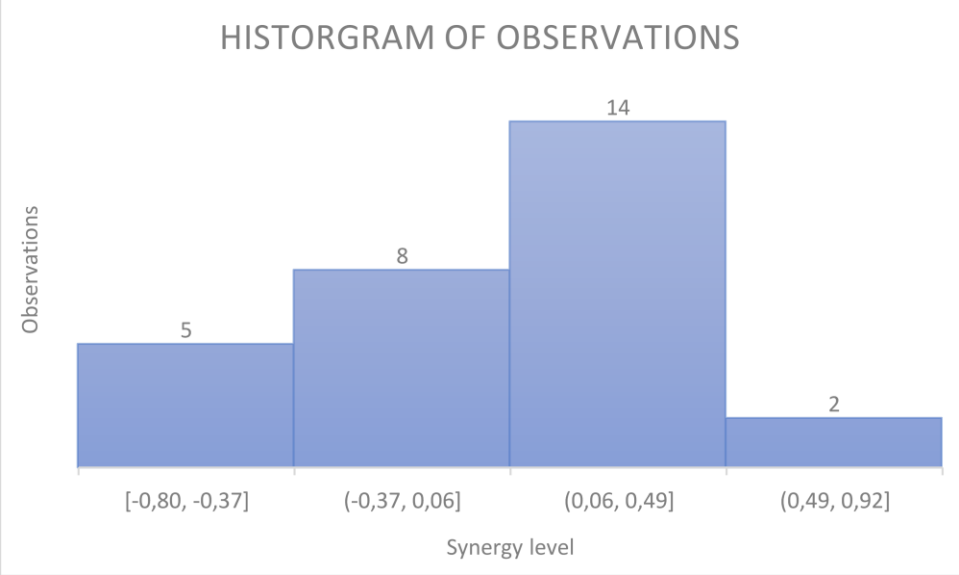

Figure 5. Histogram of synergy observations between Global GDP and Global CO_2 emission.

Most of the synergy findings fall between +0,06 - +0,49 (14 observations, see Fig. 5). This result indicates that the synergy between economic growth and carbon dioxide emissions has been strong during this period under review. In recent years we have observed a turning point in the transformation of synergy in a negative direction. This important histogram of global synergy trend analysis informs us that there have been 13 negative synergy observations and only 2 very positive observations.

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Synergy between GDP per capital and global population and global population density

Figure 6 reports synergy analysis results between Global GDP and Global population.

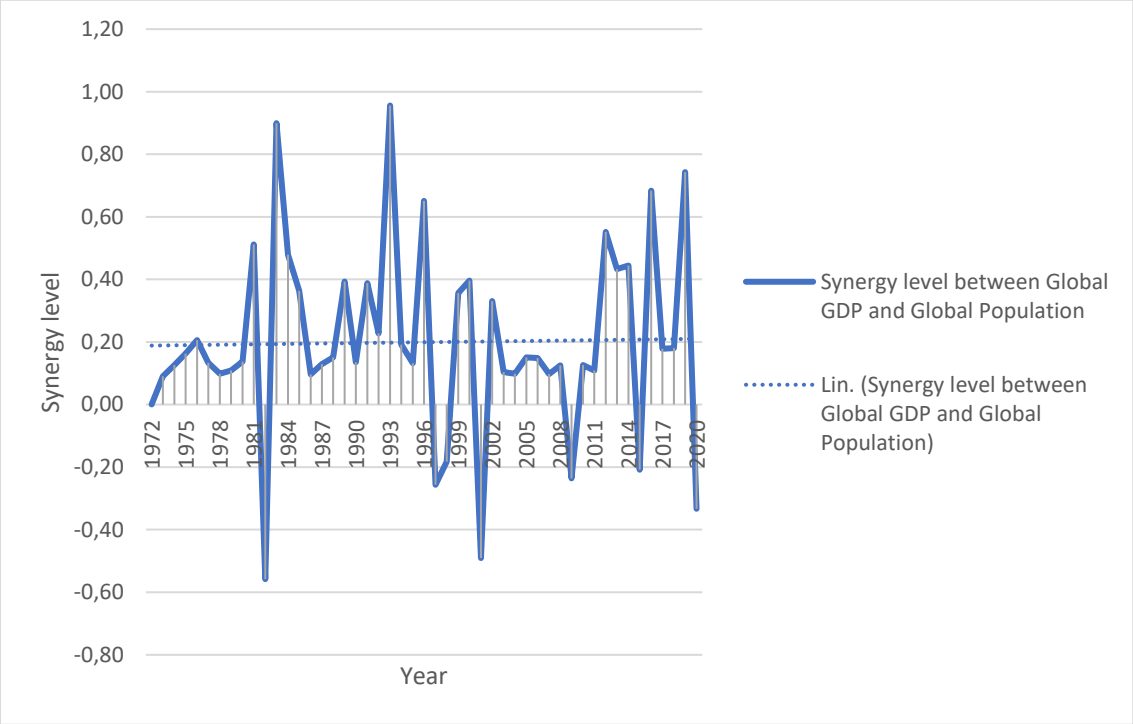

Figure 6: Synergy level between Global GDP and Global population.

The linear synergy trend curve has been fairly flat and not clearly upward-sloping or clearly downward-sloping. Of course, this is a significant scientific result, which has now been achieved through the application of global synergy analysis. Synergy trend level is +0,20. On the other hand, the Fig. 6, also shows that there have been large variations in the level of synergy.

In Fig. 7 we present a histogram of the synergy analysis between these two key variables. Fig. 7 reveals that most of the observations fall between positive synergy values +0,04 - +0,34 (26 observations). We see that histogram is positively skewed (Fig. 7). This empirical result is not a big surprise for scholars of energy economics.

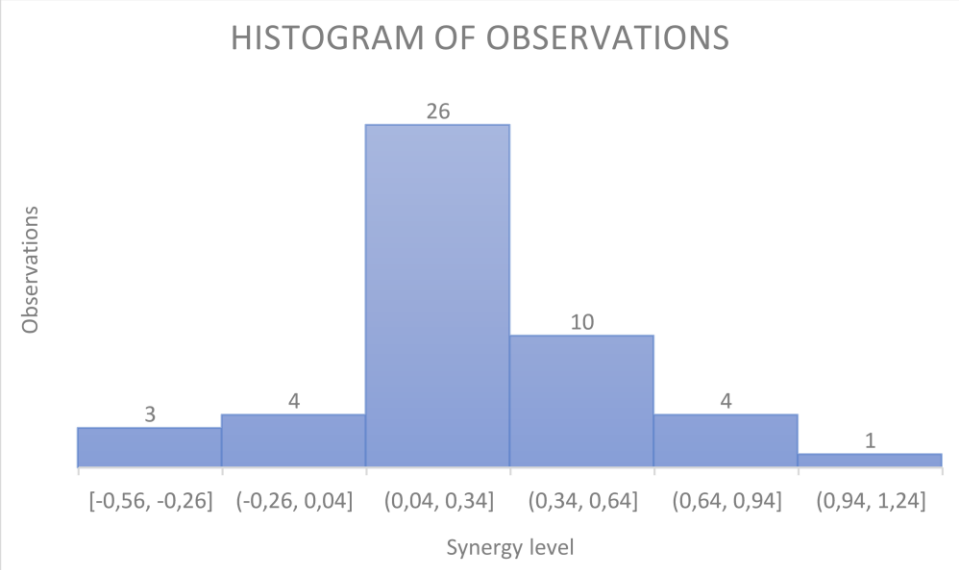

Figure 7: Histogram of synergy observations between global GDP and global population.

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Most of the observations in Fig. 7 are clearly positive synergy observations and only 7 synergy observations are negative. This finding indicates that the synergy between the variables (global GDP and global population) has been mostly positive.

In Fig. 8 we have reported a synergy analysis between global GDP and global population density.

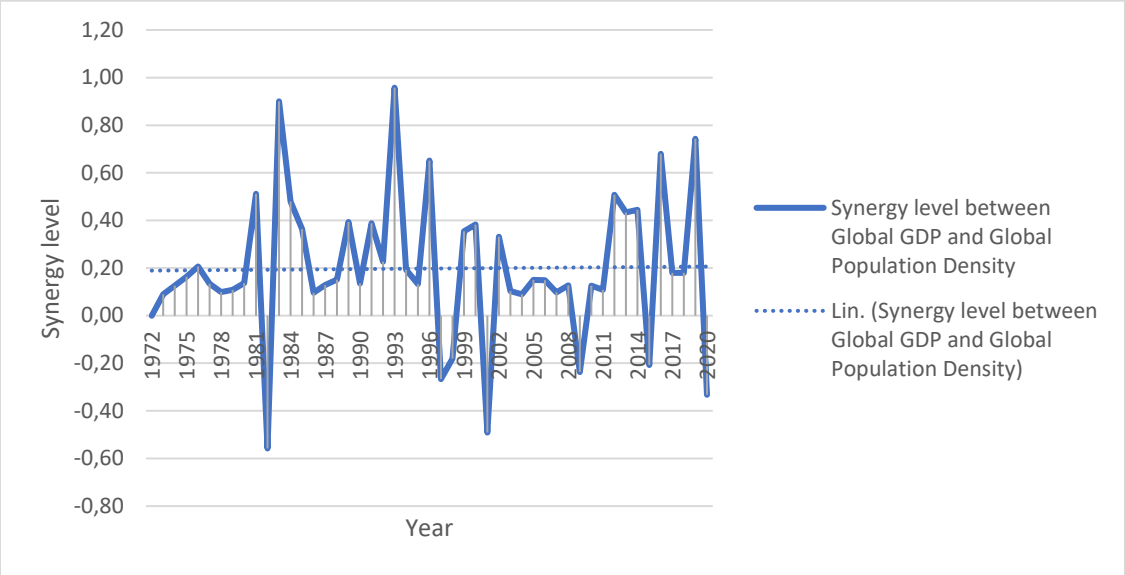

Figure 8: Synergy level between Global GDP and global population density.

The linear synergy trend curve has been fairly flat, and not clearly upward-sloping or clearly downward-sloping. The trend synergy level is +0,20. Of course, this is a significant scientific result, which has now been achieved through the application of global synergy analysis. On the other hand, Fig. 8 also shows that there have been large variations in the level of synergy. Top positive synergy observations have been over +0,9 and top negative observations have been near -0,6. Thus, synergy variations have been considerable.

In Fig. 9 we report a histogram of synergy observations between global GDP and global population density. We see that histogram of synergy observations is positively skewed in the world.

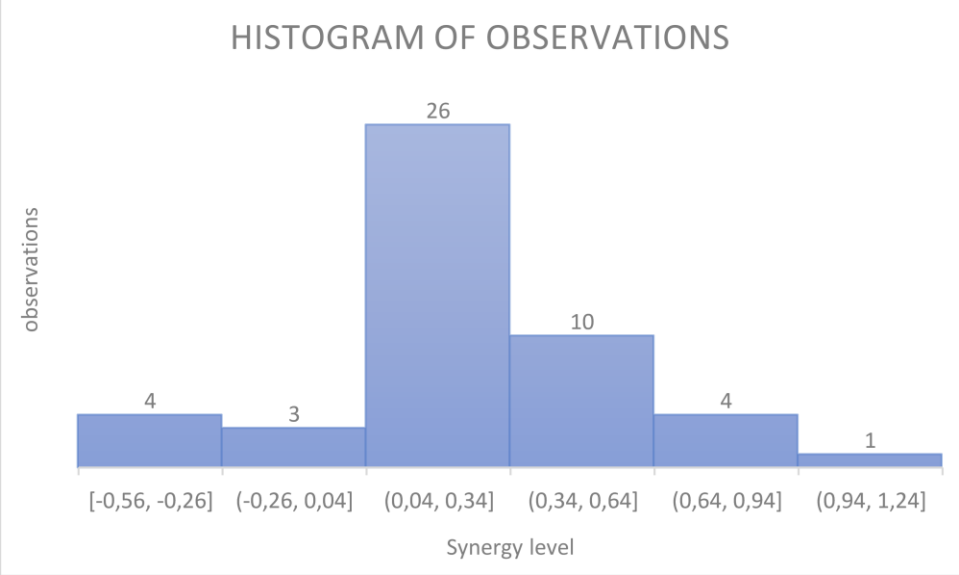

Figure 9: Histogram of synergy observations between global GDP and global population density.

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Majority of synergy values are between 0,04-0,34 (26 observations). Figure 9 informs us that most of the findings are positive synergy observations. We can cautiously conclude from this result that the development of global urbanization (with increasing population density) contributes to global economic growth, because of observed positive synergy levels.

Synergy between GDP per capital and global primary completion rate

In Figure 10 we report synergy level between global GDP and global primary completion rate, total (% of relevant age group).

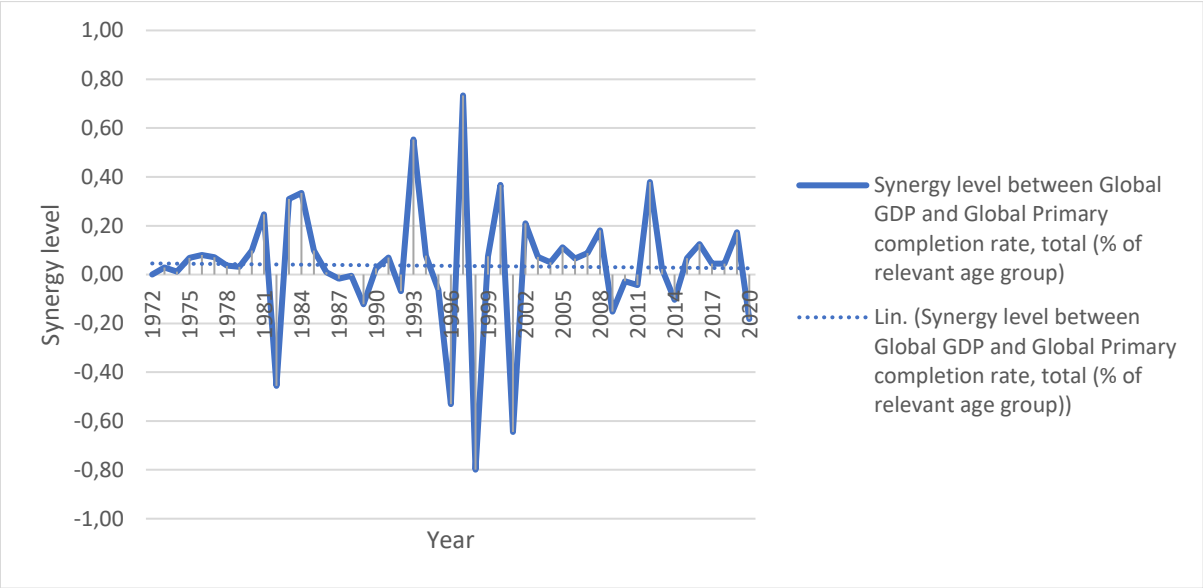

Figure 10: Synergy level between Global GDP and Global Primary completion rate.

Again, In Fig. 10, we observe a linear curve of smooth synergy, as well as large synergy variations in the historical review. The synergy level has not risen to a very high synergy level in terms of trend. It's only a little above zero. A large period of instability in terms of synergy development for the number of years in 1993-2002, when the fluctuations in synergy were really large.

In Fig. 11 we report a histogram of observations between global GDP and global primary completion rate (GPCR).

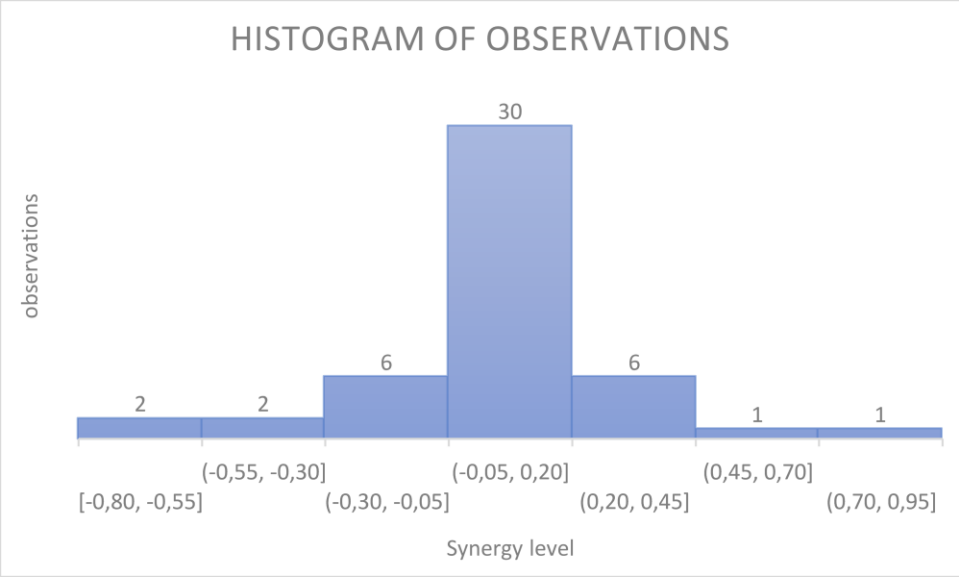

Figure 11. Histogram of synergy observations between global GDP and global Primary completion rate (GPCR)

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The histogram indicates that synergy observations are normal distributed for these critical variables. Most of synergy observations are between -0,05 - +0,20 (30 observations).

In Fig. 12 we have reported synergy level between Global GDP and global school enrolment, primary and secondary (gross), gender parity index (GPI). In Fig. 12, we observe almost a linear curve of smooth synergy, as well as large synergy variations in the historical review. The synergy level has not risen to a very high level in terms of trend. It's only a little above zero. A large period of instability in terms of synergy development for the number of years in 1993-2002, when the fluctuations in synergy were really large. This result is parallel to the previous schooling indicator analysis.

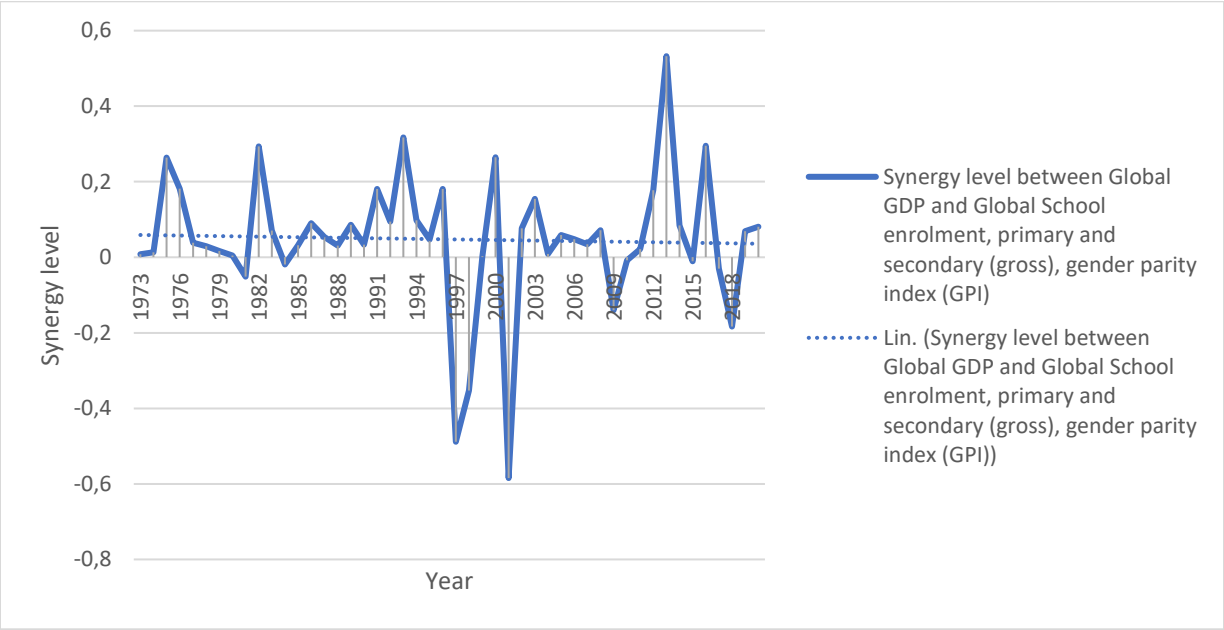

Figure 12. Synergy level between Global GDP and Global School enrolment, primary and secondary (gross), gender parity index (GPI).

In Fig 13 a histogram of synergy observation between Global GDP and Global School enrolment, primary and secondary (gross), gender parity index (GPI) is reported.

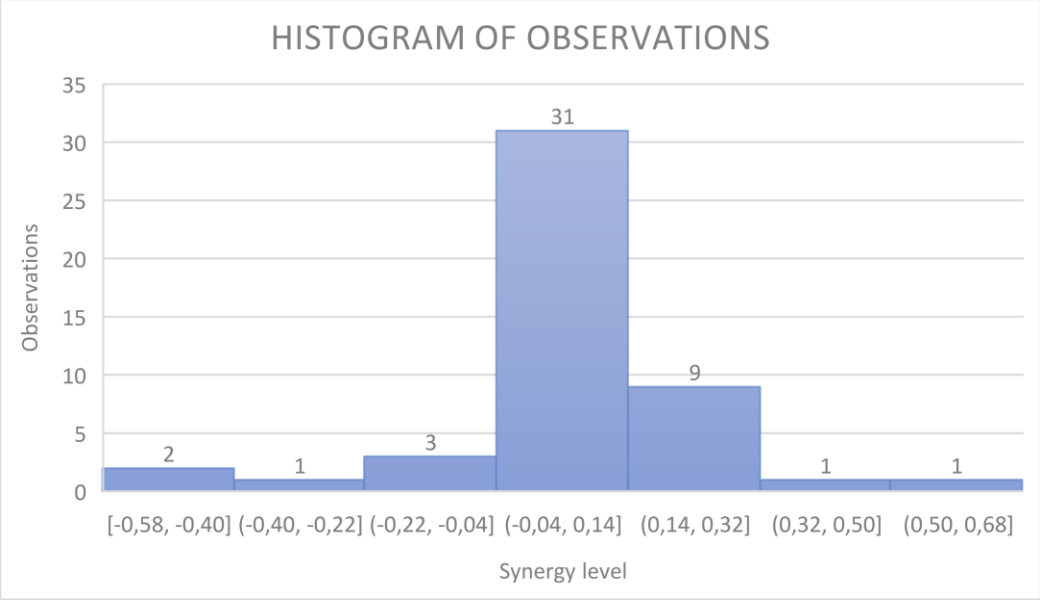

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Figure 13. Histogram of synergy observations between Global GDP and Global School enrolment, primary and secondary (gross), gender parity index (GPI).

The majority of synergy measurement findings are according to our historical review between -0,4- - +0,14 (31 observations, see Fig. 13). There are 9 observations between +0,14 - +0,32. We see that histogram is positively skewed. Mostly the synergy observations between the variables have been positive. Cautiously, we can estimate that the increase in the level of education has been creating positive synergy for global economic growth. This is a policy-relevant finding.

Conclusions

In Fig. 14 we report a statistical summary of six synergy analyses we reported in this article. A key finding is that all observed long-run average synergies were observed to be positive. The smallest deviations we observed were in the cases of two key schooling indicators. Considerable synergy deviations we observed with global population and global population density. Demographic change and urbanisation are having considerable impacts on GDP per capita developments. These demographic variables are global drivers of economic growth. Global synergy analyses verify this kind of policy assessment.

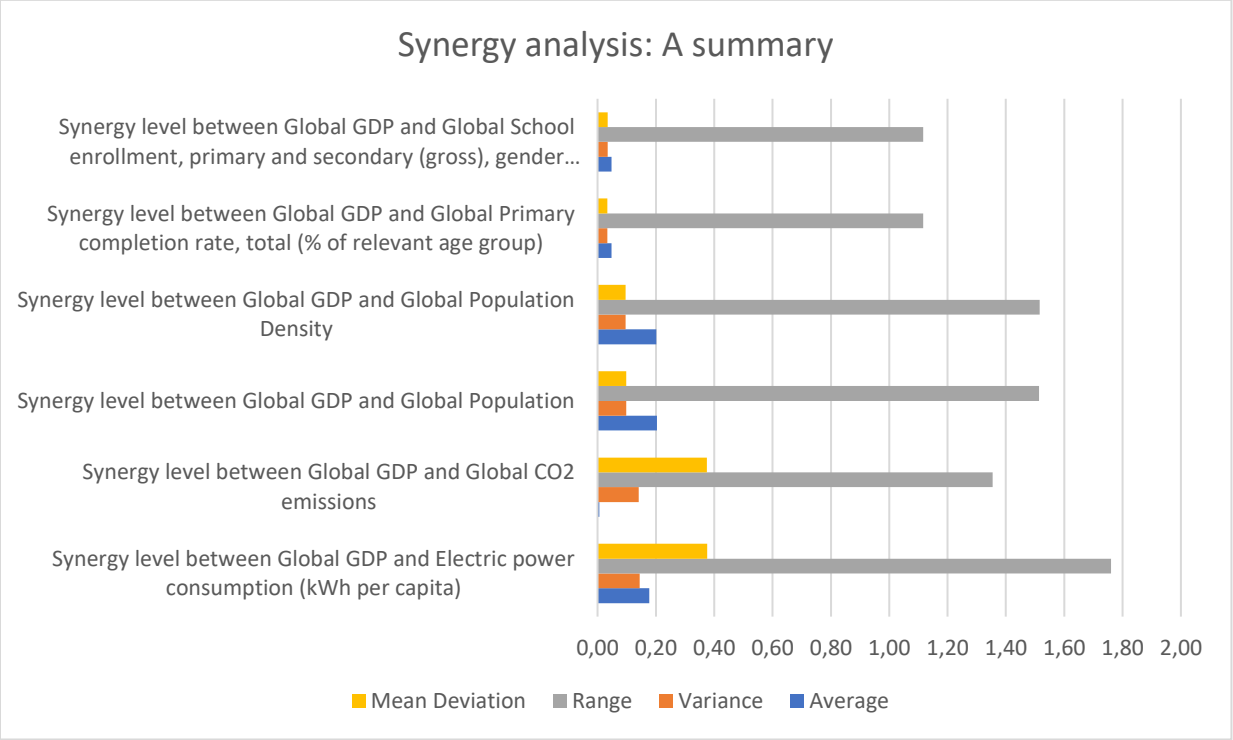

Figure 14. Global trends synergy analysis: A summary of results.

In this study, we have conducted synergy analyses for some key global trends. The results are quite interesting and raise numerous needs for further research.

One interesting thing about synergy analyses is that we can observe turning points in the interaction between synergy trends. Perhaps the most significant synergy trend turning point was found in terms of global GDP development and global carbon dioxide emissions.

ACKNOWLEDGEMENTS: We acknowledge all professional feedback from research fellows of the project Manufacturing 4.0, and from the IRIS projects, which are funded by the Academy of Finland.

FUNDING: The Strategic Research Council (SRC) at the Academy of Finland has partly funded Professor Jari Kaivo-oja, in the Manufacturing 4.0 project (MFG 4.0, Strategic Research Council, project decision n:o 335989).

The authors also want to thank the Academy of Finland for funding the "Cuban energy transformation Integration of Renewable intermittent sources in the power system (IRIS)" project, decision n:o 320229.

CONFLICT OF INTEREST: No conflicts of interest.

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 ISBN: 978-86-87043-85-5

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 ISBN: 978-86-87043-85-5

Life Cycle Costing of a Detached House in Bangkok, Thailand

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Abstract

In Thailand, the number of residential buildings in the detached house category tends to increase due to increasing consumer demand. This causes economic competition among contractors and customers who would like to construct detached houses. As a result, stakeholders in detached house construction must manage costs to the lowest possible expenses throughout the building life cycle from construction to residential use, replacing maintenance equipment, and eventual demolition. Life cycle costing is growing in popularity, especially in the field of sustainable construction. However, the use of life cycle costing in the construction industry remains restricted and plagued by practical issues. One of the major issues in the widespread use of life cycle costing in the construction stage, use stage, and end-of-life stage is a lack of knowledge of the research methods and usage of life cycle costing. This study describes a research that shows how a detached house's life cycle cost evaluation was undertaken, along with how the life cycle cost variables were defined and applied to advance a life cycle budget for the entire life cycle of a detached house. This research analyzed the life cycle cost of a detached house through a case study in Bangkok by considering diverse expenses, including construction materials, maintenance, labor, electricity, water, and demolition during service life of 50 years for the building. Costs throughout the life cycle of a detached house analyzed over 50 years amount to 4,901,775.21

 ISBN: 978-86-87043-85-5

baht. This sum may be categorized into costs for each stage of a detached house life cycle, to be used in considering detached house project development and consumer decision-making.

Keywords: Life cycle costing, Detached house, Construction, Demolition

 ISBN: 978-86-87043-85-5

1. Introduction

At present, buildings in Thailand tend to increase every year. According to the National Statistical Office [19], the demand for building construction permits varies year to year, with a 19% increase in 2020, as shown in Figure 1. The total residential area is 62,245,131 square meters, divided into the number of residential buildings equal to 38,479,227 square meters and non-residential buildings equal to 23,765,904 square meters. Single-family homes accounted for 26,652,840 square meters, followed by condominiums. The area is 3,819,701 square meters of row houses or townhouses, representing an area of 3,613,197 square meters, accounting for a spot of 2,069,965 square meters of commercial buildings. The residential building site is 1,279,225 square meters and the twin houses are 1,044,299 square meters.

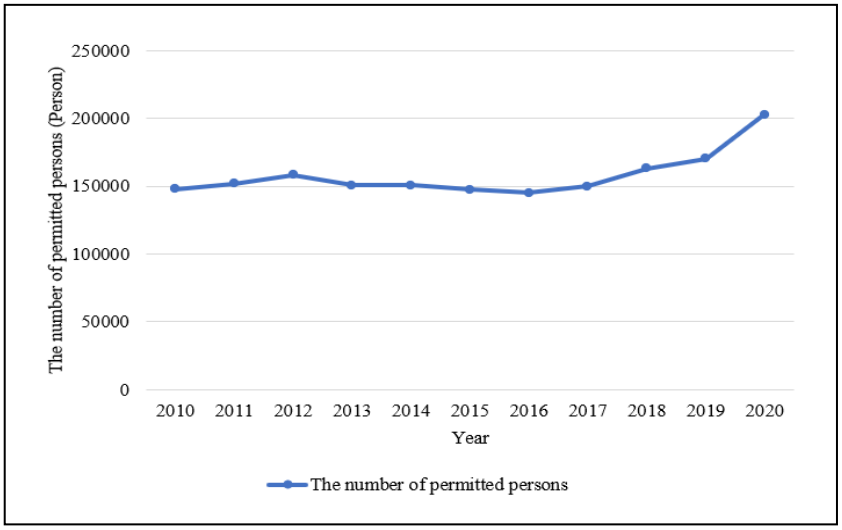

Figure 1: The graph shows the number of people who have received permission to construct buildings from 2010 to 2020.

When considering the construction of residential buildings in the category of detached houses in Bangkok and their vicinities. The construction of residential buildings in the form of houses, classified into 3 types, namely single-detached houses, row houses or townhouses, and twin houses, found that the construction area of detached houses in Bangkok had the highest volume, representing 55.68%, townhouses accounted for 43.65%, and twin houses accounted for 33.21%, as shown in Figure 2.

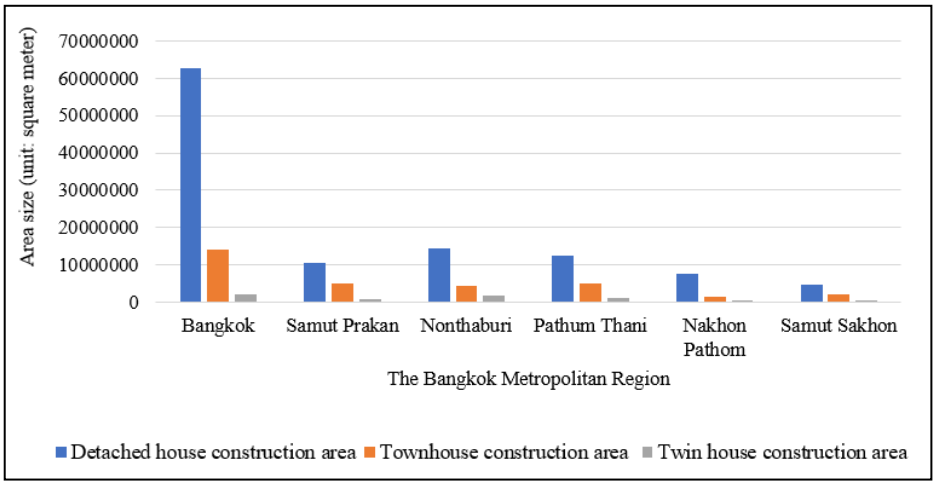

Figure 2: The graph shows the construction area of 3 types of houses: detached houses, townhouses, and twin houses in Bangkok and their vicinities

Therefore, the demand for permission to construct detached houses in Bangkok tends to increase. This causes economic competition among contractors and owners of detached houses. As a result, those involved in the construction of detached houses will have to manage the cost as low as possible throughout the life cycle of the building. It can be divided into 4 phases, including the 1. Production Stage, which is the phase of construction material production. Design to prepare for construction planning and transportation planning in construction 2. The Construction Process Stage is the phase of building construction according to the design, transportation, and installation of equipment according to the design plan of the building. 3. Use Stage refers to a building's period of use. This is the longest phase of the building's life cycle. In addition to the usage period, the building must still be maintained by means of repair and replacement of materials used in the building. The last phrase, 4. End of Life Stage, is the life expectancy of the building. The demolition and transport of these scraps will continue for disposal and recycling [22].

Thus, at each stage of a building's life cycle, there are cost of energy and water are consumed, including the cost of labor and transportation in each process that is different. This led to the use of detached house construction data from Bill of Quantities (BOQ) to be studied to analyze life-cycle costs and to be instrumental in deciding which method to operate with the lowest overall cost [1]. The long-term value of the investment over the entire life cycle of a detached house [34] so that it can be reliably presented and published for investment decision-making.

2. Objective of the Study

To study the Life Cycle Costing (LCC) of a detached house to make investment decisions for constructing a detached house.

3. Methodology

3.1. Life Cycle Costing (LCC)

In this study, the LCC was used as a method of calculating the total cost over the building's lifecycle from cradle to tomb to estimate the building's project cost. All costs incurred from construction, use, maintenance, and the demolition of buildings will be important for project owners to make decisions about the investment project building the detached house at each stage [13]. This study is an amendment from the LCC procedure based on the structure of the EN 16627 standard [21] and covers steps A1–C4 shown in Figure 3, including cost of construction materials, construction, maintenance, replacement, operation, and the end of the service life or demolition.

Therefore, the cost at each stage over the life cycle of a detached house can be described below as follows.

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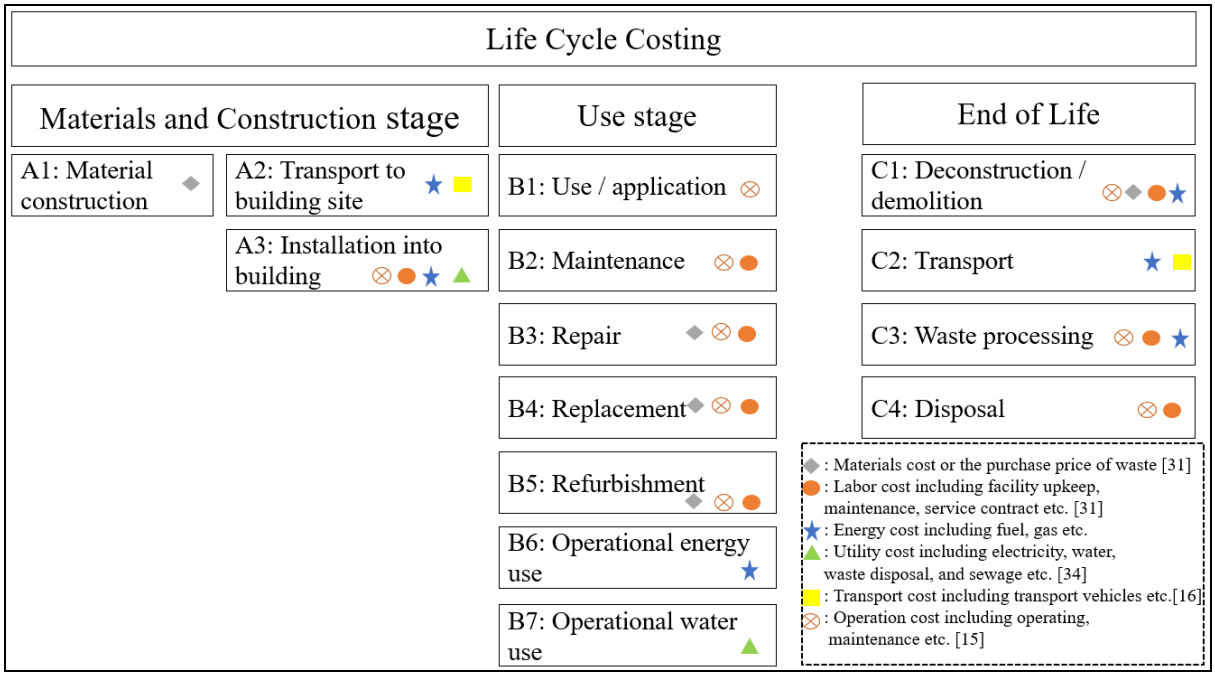

Figure 3: The four life cycle stages modified according to the EN 16627 standard.

3.1.1 Material and Construction stage (A1-A3)

The materials stage means the materials used for building construction, including the architecture being built [31]. For example, concrete, soil, sand, metal, plastic, glass, and land for construction [20]. These materials have different purposes and specific application properties. Therefore, it is the investment phase in the first part of the budget plan [2]. For this study, the cost of building materials was only taken from the BOQ and did not include the cost of the construction material production process. The construction stage means the cost of tools and equipment, including transportation costs, labor costs for the construction and installation of materials and equipment. In addition, it includes overhead costs such as water, electricity, and construction costs, which are covered until the operating costs, taxes (7%), and profit (10%). Therefore, the cost of the construction process is dependent on the contractor who determines and agrees with the owner of the building project.

3.1.2 Use stage (B1-B7)

The use stage refers to the phase of use implementation that includes use, maintenance, repair, and the replacement of damaged component equipment. In terms of costs incurred during the use phase, the costs consist of water, electricity, and liquefied petroleum gas incurred during the period of use. In addition, the cost of maintenance of a detached house has a cost of labor and equipment. In this study, maintenance was performed, including repainting the house with maintenance every 10 years, grouting every 10 years, replacing LED lights every 17 years, and spraying termite protection every 5 years. The different parts of the equipment of a detached house have different lifespans. That depends on the usage behavior as well. Therefore, these maintenance costs will be maintained according to the normal maintenance plan.

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3.1.3 End of Life stage (C1-C4)

End of Life refers to a building's end of life or demolition process, which includes labor, energy, landfill disposal, and recycling. Therefore, in this research study, it was found that, from interviews with five contractors for the demolition of detached houses, they were the only material handling managers after the demolition. The research of a detached house construction project in Sweden [22] calculated the cost of this stage and found that costs accounted for 2.5% of the total cost, which was close to the work in this study as well.

3.2. Calculation of LCC

The LCC can be used as an economic indicator to evaluate investment in a construction project. The LCC accounts for investment costs, operating costs, transportation costs, energy costs, labor costs, maintenance costs, and the system's residual value. For life cycle cost calculation, these costs are incurred over different time periods, and these future costs are converted to the Present Value (PV) in the cash flow diagram. This can calculate the total cost incurred throughout the building's lifecycle [13] as shown in Eq. (1).

$$LCC = (I + Repl - Res) + (E + W + OM\&R) \quad (1)$$

Where LCC is total the LCC in the PV Baht (฿), I is the PV of investment cost, $Repl$ is the PV of capital replacement costs, Res is the PV of residual value (resale, scrap, and salvage value), E is the PV of energy cost (liquefied petroleum gas and fuels), W is the PV of water supply cost, and $OM\&R$ is the PV of operating, maintenance, and repair costs, which is non-fuel.

For calculating the various costs in the form of PV incurred during the whole time of this case study, they can be divided into 2 parts or Eq. (2) and (3), as shown below:

Part 1 is the Single Present Value (SPV) refers to the cost that occurs once, as shown in Eq. (2).

$$PV = F_t \cdot \frac{1}{(1+d)^t} \quad (2)$$

Where PV is the present value of future cash, F_t is future cash occurring at the end of the year at t, and d is the discount rate.

Part 2 is the Uniform Present Value (UPV) means that annual expenses incurred can be equal or uneven, as shown in Eq. (3).

$$PV = A_0 \cdot \frac{(1+d)^n - 1}{d \cdot (1+d)^t} \quad (3)$$

Where PV is the present value of future cash, A_0 is the cash value that is incurred annually over n years, incurred at the end of the year t, and d is the discount rate.

When the value of future costs is calculated and converted to PV using Eq. (2) and (3), the total PV value can be used to calculate the LCC using Eq. (1).

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4. Case study description

The study selected a detached house model of the De De Rak Nam 3 project as shown in Figure 4, which is one of the 12 types of energy-saving residential housing projects in the category of detached houses by the Department of the Energy Development of Alternative Energy, Ministry of Energy [9]. The De De Rak Nam 3 Project has the concept of saving energy according to the climate of Thailand. And there is a complete list and price of construction information or BOQ, including the discount rate used to calculate 6% [3] for studying the LCC of the detached house in order to make a decision to invest in building the detached house.

Figure 4: The DEDE Rak Nam 3 detached house project design example

4.1 Material and Construction stage

This detached house has 2 floors and a total area of 365 square meters. The service life of the building is 50 years [12]. This house was modeled after construction in Bangkok, Thailand. The cost of the construction process refers to the cost of the contractor's design and construction. The homeowner is the employer for the construction of a detached house. The detailed construction information is shown in the BOQ document obtained from the manual. The manual contains the cost of construction materials, labor costs, transportation costs, and construction costs (water and electricity costs in construction), which shows the details of construction costs as summarized and shown in Table 1. The value of the land was not included in the study. This depends on location and landholdings with high variation [6].

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Table 1 Cost of construction detached house (in Thailand Baht)

No.	List	Detached house						
		Materials			**Construction facility fee**		**Labor cost**	**Transport cost**
		Unit	**Quantity**	**Cost**	**Electricity and energy consumption**	**Water supply**		
				-	46,356.73	1,496.79	-	-
A	**Structural work category**							
A-1	**Foundation structure work and pier**							
A-1.1	Driven pile (Size I: 15X15 cm. Long 5m)	Ton	23.00	125,580.00			-	3645.96
A-1.2	Piling work	Ton	23.00	-			5,290.00	-
A-1.3	Labor costs (Driven pile) (Unit: L/S is Lump Sum)	L/S	23.00	-			33,350.00	-
A-1.4	Dig the soil	m^3	13.36	-			1,670.00	-
A-1.5	Fill the soil	m^3	4.01	-			396.99	-
A-1.6	Sharp sand	m^3	2.14	970.13			194.74	474.93
A-1.7	Lean concrete (fc' 180 Ksc., Cylinder)	m^3	1.71	3,478.14			680.58	500.00
A-1.8	Concrete (fc' 210 Ksc., Cylinder)	m^3	10.28	23,222.52			4,019.48	500.00
A-1.9	Shutter boards (Thickness 2.5 inch or 0.0635 m.)	m^3	23.10	9,240.00			2,425.50	Free shipping
A-1.10	Labor costs for assembling shutter boards	m^3	33.00	-			3,465.00	
A-1.11	Crutches for fixing framework (Size 1.5× 3 x 1.5 inch.)	m^2	6.93	2,772.00			-	
A-1.12	Reinforced concrete (DB 12 mm. SD 40)	kg.	934.43	15,978.75			3,083.62	148.13
A-1.13	Annealing Wire	kg.	28.03	591.71			-	Free shipping
A-1.14	Nail	kg.	8.25	195.53			-	
A-2	**Structural work (Beams, principal post, floor, stairs and dowel rebar)**							
A-2.1	Excavation work	m^3	19.57	-			2,446.25	4,343.17
A-2.2	Foundation sand	m^3	1.13	512.26			102.83	250.78
A-2.3	Lean concrete	m^3	0.75	1,525.50			298.50	500.00
A-2.4	Concrete (fc' 210 Ksc., Cylinder)	m^3	38.87	87,807.33			15,198.17	500.00
A-2.5	Concrete (fc' 210 Ksc., Cylinder) mixed with waterproofing agent.	m^3	26.57	64,219.69			10,388.87	500.00
A-2.6	Shutter boards (Thickness 2.5 inch or 0.0635 m.)	m^2	526.72	210,688.00			-	Free shipping
A-2.7	Labor costs for assembling shutter boards	m^2	752.46	-			79,008.30	
A-2.8	Crutches for fixing formwork (Size 1.5× 3 X 1.5 inch)	m^2	158.02	63,208.00			-	
	- DB 12 mm. SD 40	kg.	4,176.16	71,412.34			13,781.33	662.00

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Table 1 Cost of construction detached house (in Thailand Baht) (continued)

No.	Work category/activities/components	Detached house						
		Materials			Construction facility fee		Labor cost	Transport cost
		Unit	Quantity	Cost	Electricity and energy consumption	Water supply		
A-2.9	Reinforced concrete							
	- RB 6 mm. SR 24	kg.	669.01	12,289.71			2,742.94	106.05
	- RB 9 mm. SR 24	kg.	3,587.50	62,924.75			14,708.75	568.69
	- DB 12 mm. SD 40	kg.	4,176.16	71,412.34			13,781.33	662.00
A-2.10	Annealing Wire	kg.	252.37	5,327.53			-	Free shipping
A-2.11	Nail	kg.	188.11	4,458.21			-	
A-2.12	Precast concrete slabs work							
	- Precast concrete slabs flat sheet type width 0.35 m., thickness 0.05 m. (Safety load 150 kg. /sq.m.)	m^2	127.50	28,050.00			7,650.00	1,414.80
	- Overlay concrete (Topping) fc' 210 Ksc. (Cylinder), thickness 0.05 m.	m^3	6.38	14,412.42			2,494.58	1,415.91
	- RB 6 mm. SR 24	kg.	356.64	6,551.48			1,462.22	56.53
	- RB 9 mm. SR 24 (Additional roof@ 0.20 m.)	kg.	27.23	477.61			111.64	4.32
A-2.13	Termite control system (Pipe system and solution)	m^2	170.00	20,400.00			-	Free shipping
A-3	**Structural work (Roof)**							
A-3.1	Concrete fc' 210 Ksc. (Cylinder)	m^3	12.20	27,559.80			4,770.20	500.00
A-3.2	Shutter boards	m^2	101.44	40,576.00			-	Free shipping
A-3.3	Labor costs for assembling shutter boards	m^2	144.92	-			15,216.60	
A-3.4	Crutches for fixing formwork (Size 1.5× 3 inch.)	m^2	30.43	12,172.00			-	
A-3.5	Reinforced concrete							
	- RB 6 mm. SR 24	kg.	24.17	444.00			99.10	3.83
	- RB 9 mm. SR 24	kg.	562.87	10,339.92			2,307.77	89.23
	- DB 12 mm. SD 40	kg.	1,060.28	18,130.79			3,498.92	168.08
A-3.6	Annealing Wire	kg.	49.42	1,042.76			-	Free shipping
A-3.7	Nail	kg.	36.23	858.65			-	
A-3.8	Structural steel (Roof structure)							
	- Square Tube 100 x 100 x 3.2 mm.	kg.	165.65	2,998.27			2,319.10	
	- Rectangular Tube 150 x 50 x 3.2 mm.	kg.	232.29	4,204.45			3,252.06	36.82
	- Rectangular Tube 125 x 50 x 3.2 mm.	kg.	379.13	6,862.25			5,307.82	60.10
	- Rectangular Tube 100 x 50 x 3.2 mm.	kg.	3,385.13	61,270.85			47,391.82	536.61
	- Rectangular Tube 75 x 38 x 3.2 mm.	kg.	2,213.56	40,065.44			30,989.84	350.89
	- Light Lip Channel 150 x 50 x 20 x 3.2 mm.	kg.	1,967.16	35,605.60			27,540.24	311.83
	- Plate 10 mm.	m^2	52.99	1,414.30			495.46	Free shipping
	- Rust-proof paint of TOA or equivalent	m^2	427.61	23,946.16			14,966.35	

Table 1 Cost of construction detached house (in Thailand Baht) (continued)

No.	Work category/activities/components	Detached house						
		Materials			Construction facility fee		Labor cost	Transport cost
		Unit	Quantity	Cost	Electricity and energy consumption	Water supply		
B	**Architecture work category**							
B-1	**Floor decoration**							
B-1.1	F1 – Tile finish, size 24'' × 24''	m^2	125.80	44,030.00			31,450.00	Free shipping
B-1.2	F3 – Wood-patterned tile finish 24'' × 24''	m^2	33.90	10,170.00			8,475.00	
B-1.3	F4 – Ceramic tile finish 12'' × 12''	m^2	27.90	7,812.00			5,022.00	
B-1.4	F5 – Smooth cement (Parking) thickness 15 mm.	m^2	87.50	1,750.00			2,625.00	
B-1.5	PVC Hardwood baseboard ½''×4'' x 2 m. (Lower floor)	m.	52.00	3,120.00			2,340.00	
B-2	**Construction material and wall decoration**							
B-2.1	Lightweight concrete wall size 1 layer	m^2	385.40	77,080.00			30,832.00	
B-2.2	Finish mortar plaster interior wall	m^2	344.00	15,480.00			27,520.00	
B-2.3	Finish mortar plaster exterior wall	m^2	286.20	12,879.00			22,896.00	
B-2.4	Post and lintel size 0.10 × 0.10 m.	m.	215.00	15,050.00			10,750.00	
B-2.5	Pole corner bead	m.	300.00	7,500.00			10,500.00	
B-2.6	W4-tiled wall size 12''× 12'' high to attic ceiling	m^2	60.00	16,800.00			10,800.00	
	White-wash	m^2	60.00	3,600.00			4,200.00	
B-2.7	Other							
	- Stucco cornices	m.	65.00	7,150.00			4,550.00	
B-2.8	The wall is covered with a smart board.	m^2	170.00	17,000.00			17,000.00	
B-3	**Ceiling decoration**							
B-3.1	C2 – Moisture resistant gypsum board ceiling, thickness 9 mm., plastered with galvanized steel frame @ 0.60x0.60m. + insulation 3" thick glass fiber with aluminum foil cladding	m^2	81.65	41,641.50			-	
B-3.2	C1 – Gypsum board ceiling, thickness 9 mm., conventional type, galvanized steel frame @ 0.60x0.60m. + 3-inch-thick glass wool insulation with aluminum foil cladding.	m^2	124.60	59,808.00			-	
B-3.3	C3 – Ceiling of Elephant Brand Smart Board, thickness 4 mm., galvanized steel frame C-Line C75 No. 24@0.60m. + 3 inches thick glass wool insulation with aluminum foil cladding.	m^2	261.90	98,212.50			-	
B-4	**Paint work**							
B-4.1	Interior paint	m^2	344.00	9,288.00			9,976.00	
B-4.2	Exterior paint	m^2	286.20	8,586.00			8,299.80	

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Table 1 Cost of construction detached house (in Thailand Baht) (continued)

No.	Work category/activities/components	Detached house						
		Materials			Construction facility fee		Labor cost	Transport cost
		Unit	Quantity	Cost	Electricity and energy consumption	Water supply		
B-4.3	Interior ceiling paint	m^2	206.25	6,187.50			6,187.50	
B-4.4	Exterior ceiling paint	m^2	261.90	9,166.50			9,428.40	
B-4.5	Eave wood color, over the eaves (material + strength)	m.	90.30	3,160.50			2,257.50	Free shipping
B-4.6	Oil paint on the bottom of the hardwood ½"x4"	m.	90.30	2,709.00			1,806.00	
B-4.7	Scaffolding	(L/S)	1.00	3,000.00				
B-5	**Door-window and equipment work (as specified in form GG-0.03)**							
B-5.1	Door work (including wooden door color)							
B5.1.1	Door 1	Set	1.00	9,840.00				
B5.1.2	Door 2	Set	2.00	95,000.00				
B5.1.3	Door 3	Set	1.00	30,000.00				
B5.1.4	Door 4	Set	2.00	20,500.00				
B5.1.5	Door 5	Set	3.00	14,400.00				
B5.1.6	Door 6	Set	1.00	20,500.00				
B5.1.7	Door 7	Set	3.00	9,000.00				
B5.1.8	Door 8	Set	2.00	9,600.00				
B5.1.9	Door 9	Set	2.00	15,600.00				
B-5.2	Window work							
B-5.2.1	Window 1	Set	2.00	4,025.00				
B-5.2.2	Window 2	Set	2.00	1,500.00				
B-6	**Sanitary ware work**							
B-6.1	Toilet 1	Set	1.00					
B-6.1.1	Flush toilet	Set	1.00	4,628.00				
B-6.1.2	Rinsing hose with stop valve	Set	1.00	150.00				
B-6.1.3	Toilet paper holder	Set	1.00	94.00				
B-6.1.4	Basin	Set	1.00	2,440.00				
B-6.1.5	Single Basin Faucet	Set	1.00	934.60				
B-6.1.6	Clothes rack	Set	1.00	300.0				
B-6.1.7	Shelf	Set	1.00	315.00				
B-6.1.8	Floor drain strainer with odor trap with filter cap	Set	1.00	231.00				
B-6.1.9	Mirror, thickness 3 mm.	Set	1.00	350.00				
B-6.1.10	Washbasin navel	Set	1.00	172.20				
B-6.1.11	Chromium duct	Set	1.00	90.00				
B-6.1.12	Water pipe	Set	1.00	570.00				

Table 1 Cost of construction detached house (in Thailand Baht) (continued)

No.	Work category/activities/components	Detached house						
		Materials			Construction facility fee		Labor cost	Transport cost
		Unit	Quantity	Cost	Electricity and energy consumption	Water supply		
B-6.1.13	Others							
	- Chrome plated faucet ERA ½"	Set	1.00	145.00				
	- Red handle field tap with rubber hose holder.	Set	1.00	145.00				Free shipping
B-6.2	Toilet 2							
B-6.2.1	Flush toilet	Set	1.00	4,628.00				
B-6.2.2	Rinsing hose with stop valve	Set	1.00	150.00				
B-6.2.3	Toilet paper holder	Set	1.00	94.00				
B-6.2.4	Basin	Set	1.00	2,440.00				
B-6.2.5	Single Basin Faucet	Set	1.00	834.60				
B-6.2.6	Hand shower set with hook	Set	1.00	670.00				
B-6.2.7	Clothes rack	Set	1.00	300.00				
B-6.2.8	Dish soap	Set	1.00	94.00				
B-6.2.9	Shelf	Set	1.00	315.00				
B-6.2.10	Floor drain strainer with odor trap with filter cap	Set	2.00	462.00				
B-6.2.11	Mirror, thickness 3 mm.	Set	1.00	350.00				
B-6.2.12	Washbasin navel	Set	1.00	172.20				
B-6.2.13	Chromium duct	Set	1.00	90.00				
B-6.2.14	Water pipe	Set	1.00	570.00				
B-6.3	Toilet 3	Set	1.00					
B-6.3.1	Flush toilet	Set	1.00	4,628.00				
B-6.3.2	Rinsing hose with stop valve	Set	1.00	150.00				
B-6.3.3	Toilet paper holder	Set	1.00	94.00				
B-6.3.4	Basin	Set	1.00	2,440.00				
B-6.3.5	Single Basin Faucet	Set	1.00	834.60				
B-6.3.6	Hand shower set with hook	Set	1.00	670.00				
B-6.3.7	Clothes rack	Set	1.00	300.00				
B-6.3.8	Dish soap	Set	1.00	94.00				
B-6.3.9	Shelf	Set	2.00	315.00				
B-6.3.10	Floor drain strainer with odor trap with filter cap	Set	1.00	462.00				
B-6.3.11	Mirror, thickness 3 mm.	Set	1.00	350.00				
B-6.3.12	Washbasin navel	Set	1.00	172.20				
B-6.3.13	Chromium duct	Set	1.00	90.00				
B-6.3.14	Water pipe	Set	1.00	570.00				

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Table 1 Cost of construction detached house (in Thailand Baht) (continued)

No.	Work category/activities/components	Detached house						
		Materials			Construction facility fee		Labor cost	Transport cost
		Unit	Quantity	Cost	Electricity and energy consumption	Water supply		
B-7	**Roof work**							
B-7.1.1	- Corrugated roof tile, small corrugated, 54x120 cm.	Sheets	823.00	34,566.00				
B-7.1.8	- Other equipment	L/S	1.00	10,000.00				Free shipping
B-8	**Stairs work**							
B-8.1	ST1 (Main stair)							
	- baby lying on the stairs	Part	14.00	7,560.00				
	- Staircase	m^2	1.25	587.50				
	- Prefabricated wooden wall cornice ½"x4"	m.	16.40	1,148.00			12,000.00	
	- Labor cost for installing stairs	(L/S)	1.00	-				
	- Plastering and paint work under the stairs	(L/S)	1.00	2,500.00				
	- Adjust the cement sand steps	(L/S)	1.00	3,500.00				
	- Handrail	m.	12.35	1,800.00				
B-9	**Miscellaneous work**							
B-9.1	Sunshade							
B-9.1.1	Sunshade 1	Set	7.00	14,000.00				
B-9.1.2	Sunshade 2	Set	5.00	55,000.00				
B-9.1.3	Sunshade 3	Set	2.00	16,875.00				
B-9.1.4	Sunshade 4	Set	1.00	8,575.00				
B-9.2	Guard rail							
B-9.2.1	Balcony railing 1	Set	7.00	15,750.00				
B-9.2.2	Balcony railing 2	Set	3.00	12,379.50				
B-9.2.3	Balcony railing 3	Set	8.00	86,400.00				
B-9.2.4	Balcony railing 4	Set	1.00	2,025.00				
B-9.2.5	Balcony railing 5	Set	1.00	7,425.00				
C	**Electrical System Category**							
C-1	**Sub-panel, Circuit Breaker and electric meter**	Set	1.00	1,465.00			110.00	
	- CONSUMER UNIT (CU) 14 circuits	Set	1.00	1,100.00			110.00	
	- Molded Case Circuit Breaker (MCCB) 2P,100AT/100AF, Ics 10 KA	Set	6.00	660.00			660.00	
	- Miniature Circuit Breaker (MCB) 1P,16AT	Set	4.00	5,800.00			440.00	
	-RCBO 1P,16AT (6kA, 30mA)	Set	2.00	2,900.00			220.00	
	-RCBO 1P,20AT (6kA, 10mA)	Set	1.00	800.00			200.00	
	-Ground wire, size 5/8 inches, length 2.4 meters	Set	1.00	1,900.00			400.00	
	-Ready-made pond 30X40X40 cm.	Set	1.00	1,465.00			110.00	

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Table 1 Cost of construction detached house (in Thailand Baht) (continued)

No.	Work category/activities/components	Detached house						
		Materials			Construction facility fee		Labor cost	Transport cost
		Unit	Quantity	Cost	Electricity and energy consumption	Water supply		
C-2	**Wires and conduits**							
	-IEC01 (THW) 35 SQ.MM. (MAIN FEEDER)	m.	50.00	5,615.50			1,500.00	Free shipping
	-IEC01 (THW) 10 SQ.MM. (GROUND MAIN FEEDER)	m.	15.00	521.40			240.00	
	-IEC01 (THW) 4 SQ.MM.	m.	370.00	4,488.10			3,700.00	
	-IEC01 (THW) 2.5 SQ.MM.	m.	959.00	7,710.36			6,713.00	
	-NYY 2.5 -1C SQ.MM.	m.	30.00	617.70			360.00	
	-NYY 1.5 -1C SQ.MM.	m.	30.00	528.90			300.00	
	-COAXIAL RG6	m.	40.00	192.00			120.00	
	-TIEV 0.65-4C	m.	20.00	187.00			120.00	
	-VCT 2C-2.5 SQ.MM.	m.	66.00	2,574.00			792.00	
	-DIA. 1 ¼ inch HDPE-PN6	m.	10.00	160.00			190.00	
	-DIA. 1-inch HDPE-PN6	m.	15.00	330.00			270.00	
	-DIA. 2 inches uPVC	m.	25.00	1,932.00			875.00	
	-DIA. ¾ in. uPVC	m.	13.00	235.95			299.00	
	-DIA. ½ inch uPVC	m.	558.00	7,834.32			11,160.00	
	-Flexible Metal DIA. ½ inch pipe	m.	66.00	290.40			726.00	
	-Fitting Accessories	Collectively	1.00	-			6,058.00	
C-3	**Electric lamp**							
	-Round ceiling lamp using COMPACT LED lamp 2X13W/ E27	Set	6.00	2,520.00			66.00	
	-Lamp DOWNLIGHT 4-6 inches using - COMPACT LED 13W/ E27 cap	Set	21.00	5,250.00			2,415.00	
	-Lamp DOWNLIGHT 4-6 inches, use COMPACT LED 13W/E27 (insect-proof) lamp	Set	10.00	2,500.00			1,150.00	
	-Ceiling lamp T8 LED 18W/Lamp type G13	Set	8.00	2,560.00			920.00	
	-Ceiling lamp T8 LED 18W/G13 cap type (Insect proof)	Set	1.00	320.00			115.00	
	-COMPACT LED bulb 13W/ E27 cap	Set	43.00	5,160.00				
	-T8 LED lamp 18W/Lamp type G13	Set	9.00	1,980.00				
C-4	**Switch and socket**							
	-1-way electrical switch	Set	29.00	870.00			2,320.00	
	-2-way electrical switch	Set	2.00	112.00			170.00	
	-1 switch cover with accessories	Set	9.00	198.00				
	-2 switch covers with accessories	Set	6.00	132.00				

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Table 1 Cost of construction detached house (in Thailand Baht) (continued)

No.	Work category/activities/components	Detached house						
		Materials			Construction facility fee		Labor cost	Transport cost
		Unit	Quantity	Cost	Electricity and energy consumption	Water supply		
	-3 switch covers with accessories	Set	2.00	44.00				
	-4 switch covers with accessories	Set	2.00	44.00				Free shipping
	-Electrical socket type double socket 16 A. 250 V.	Set	17.00	2,210.00			1,530.00	
	-Electrical socket type double socket 16 A. 250 V. (waterproof)	Set	3.00	390.00			345.00	
	-2 electrical socket covers with accessories	Set	17.00	374.00				
	-Cover for 2 electrical sockets with accessories (waterproof type)	Set	3.00	66.00				
C-5	**Other (MTV, TEL, Doorbell)**							
	TV OUTLET	Set	4.00	1,200.00			360.00	
	TAB OFF	Set	4.00	1,320.00			360.00	
	SPLITTER 4-way	Set	1.00	950.00			115.00	
	LINE AMP	Set	4.00	560.00			360.00	
	TELEPHONE OUTLET	Set	2.00	400.00			180.00	
	Wall bell	Set	1.00	300.00			80.00	
	Wall bell switch, fence post, waterproof type	Set	1.00	200.00			80.00	
D	**Waterworks and Sanitation**							
D-1	**Water supply pipe system**	m.	2.50	24.95				
	Size ½ inches (Normal Size)	m.	46.50	585.44			75.00	
	Size ¾ inches (Normal Size)	Collectively	1.00	61.03			1,395.00	
	Couplings and pipe fittings	Set	1.00	105.00			18.31	
	Hose Bibb (Size ½ inch)	Set	6.00	1,584.00			100.00	
	Water valve (Gate Valve)	Set	1.00	1,135.00			900.00	
	Water Meter	Set	1.00	155.00			100.00	
	½" field tap	Set	1.00	11,600.00			50.00	
	Automatic water pump 250 W	Set	1.00	4,590.00			3,480.00	
	1,500 liters prefabricated above ground water tank	Collectively	1.00	1,916.00			1,377.00	
	Couplings and pipe fittings	Pillar	4.00	1,808.00			575.07	
	P.C. PILE 0.12x0.12x6.00 m.	Pillar	4.00				2,192.00	
	Cutting pile head	m.	2.50	22.65			1,600.00	
	Coarse sand, compacted underside	m^3	0.05	101.70			4.55	
	Lean concrete	m^3	0.05	118.35			19.90	500.00
	Structural concrete 280 ksc. (Cylindrical)	m^3	0.05	80.00			21.80	500.00
	General wood, 50% off	m^2	0.20	24.95			26.60	Free shipping

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Table 1 Cost of construction detached house (in Thailand Baht) (continued)

No.	Work category/activities/components	Detached house						
		Materials			Construction facility fee		Labor cost	Transport cost
		Unit	Quantity	Cost	Electricity and energy consumption	Water supply		
D-2	**Sewer system waste water and sewage**							
	PVC pipe, quality class 8.5, according to TIS standards 17-2523							Free shipping
	- Size 2 inches	m.	25.30	1,081.58				
	- Size 4 inches	m.	21.60	3,283.20			1,012.00	
	-Couplings and pipe fittings	Collectively	1.00	436.48			2,160.00	
	-Septic tank, buried in the soil, size 1,200 liters	Set	1.00	4,790.00			130.94	
	-FD	Set	5.00	1,000.00			1,437.00	
	Septic tank receiving structure							
	-P.C. PILE 0.12x0.12x6.00 m.	Pillar	4.00	1,809.84			2,192.00	
	-Cutting pile head	Pillar	4.00	-			1,600.00	
	-Excavation work	m^3	1.20	-			118.80	
	-Coarse sand, compacted foundation	m^3	0.05	22.67			4.55	
	-Lean concrete	m^3	0.05	101.70			19.90	500.00
	-Structural concrete 280 ksc. (Cylindrical)	m^3	0.05	118.35			21.80	500.00
	-General wood, 50% off	m^3	0.20	80.00			26.60	Free shipping
D-3	**Air duct work**							
	PVC pipe, quality class 8.5, according to TIS standards 17-2523							
	- Size 2 inches	m.	13.50	577.13			540.00	
	Couplings and pipe fittings	Collectively	1.00	57.71			17.31	
D-4	**Building's rainwater drainage system**							
	PVC pipe, quality class 8.5, according to TIS standards 17-2523							
	Size 2 inches	m.	27.80	1,188.45			2,224.00	
D-5	**Drainage system work around the area**							
	Cement pipe Ø 0.20 m.	m.	83.00	9,960.00			3,984.00	
	Ready-made cement wastewater pond 0.40 x 0.40 m.	Set	11.00	8,433.37			1,100.00	
	Garbage trap	Set	1.00	800.00			150.00	
	Grease trap installed under the sink	Set	1.00	2,900.00			200.00	
	Grease trap 28 liters	Set	1.00	3,700.00			200.00	
	Excavation work	m^3	3.00	-			297.00	
	Trap	Set	1.00	766.67			100.00	
Total cost (include operation profit 10% and VAT 7%)				2,719,873.55	43,324.05	1,398.86	797,877.59	23,157.40

4.2 Use stage

The cost of use in the process of using a detached house is considered from the point of view of the user, consisting of the cost of using it for basic home appliances for Thai people [35]. The cost of electricity consists of a water pump, an air conditioner, a water heater, 98 fluorescent lights, a refrigerator, and a television. The average power consumption of electrical appliances depends on the area of the room. number of users or residents) Therefore, the average consumption of electrical appliances from [24] and [5] was referenced to calculate the electricity cost of the Metropolitan Electricity Authority [17] is shown in Eq. (4), (6), (7) and (8). The number of utilization units of air conditioners Eq. (5) [11] and water supply costs (Residence type) from Eq. (9) refer to the Metropolitan Waterworks Authority [18], including the energy costs of households in Bangkok, namely households gas the National Statistical Office [1] is shown in Table 2. And maintenance, repairing and replacement value of this detached house is shown in Table 3.

$$Customer\ used\ energy\ (kWh\ or\ Unit/Month) = \frac{Electric\ power\ \times Period\ of\ use\ \times 30\ days}{1000} \quad (4)$$

Where the unit of electric power is Watt (W), and the electricity usage period of each electrical appliance (Hour/day).

In addition, to calculate the quantity consumption of air conditioners, there is a specific calculation formula as follows.

$$Quantity\ consumption\ of\ air\ conditioner\ (Unit/Month) = \frac{Cooling\ capacity/SEER}{1000} \times Period\ time\ of\ use\ \times 30\ days \quad (5)$$

Where the unit of cooling capacity is BTU (British Thermal Unit), SEER is the Seasonal Energy Efficiency Ratio (Unit: BTU/hour/Watt), and the unit of period time in use is hours per day.

Next, when we know the total number of electrical units in the house. Therefore, the base electricity tariff (Baht) of the residential buildings in this study can be calculated using residential service on progressive and service charges as specified by the Metropolitan Electricity Authority.

$$F_t\ (Baht) = Total\ \ customer\ used\ energy\ \times F_t \quad (6)$$

Where F_t (Float time) is the cost (Baht/unit) of generating electricity that the utility cannot control, such as fuel prices, inflation, foreign exchange rates, etc.

$$VAT\ 7\%\ (Baht) = (Base\ electricity\ tariff + F_t) \times 7\% \quad (7)$$

Where VAT is a tax that electricity users must pay as well, which will be charged according to Thai law at 7%.

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$$Electricity\ bill\ (Baht) = Base\ electricity\ bill + F_t + VAT\ (7\%) \quad (8)$$

Where the electricity bill is the net cost that electricity consumers must pay, which includes base electricity, Ft, and VAT7%.

$$Water\ tariffs\ (Baht) = (Volume\ of\ water \times Water\ price) + Service\ charge + VAT\ (7\%) \quad (9)$$

Where the unit of volume water in use is cubic meters (cu.m.), the unit of water price is Baht per cu.m., the unit of service charge is Baht per month and depends on water meter size, with VAT at 7% following Thai law.

Table 3 The annual and lifetime of electricity, energy, and, utilities cost in the use stage

No.	Electricity/energy/utilities source	Annual cost (Baht/year)	Life time cost (Baht)
1.	Electricity	63,568.18	1,001,955.27
2.	Energy costs (Household Gas) [25]	636.00	10,024.57
Total electricity and energy cost		**64,204.18**	**1,011,979.84**
3.	Water supply	5,229.73	261,486.60
Total utilities cost		**5,229.73**	**82,430.51**
Total all		**69,433.91**	**1,094,410.35**

Table 4 The annual and lifetime of maintenance, repairing and replacement costs in the use stage

No	Maintenance, repairing and replacement activity	Lifetime of materials (Year)	Cost (Baht/time)	Life time cost (Baht)
1.	Sealant	10 [27]	1,710.00	2,044.82
2.	House paint			
	- Indoor	10 [8]	19,264.00	23,035.89
	- Outdoor	10 [8]	16,885.80	20,192.04
3.	Injecting anti-termite solution	5	20,400.00	57,042.48
4.	LED lamps 13W and 18W	17	20,290.40	10,333.90
Total maintenance and repairing costs				**112,649.13**

4.3 End of life stage

The cost of the end-of-life stage, which is the final stage that covers deactivation, the layoff of construction and maintenance, and demolition. This level was assessed through interviews with five building and house demolition contractors. It was found that the average demolition cost was 310 Baht per square meter. All costs associated with the end of life include demolition, labor costs, transportation costs, and the cost of dismantling waste management shown in Table 5. The total cost of demolition of detached houses is approximately 113,150 Baht. Incorporating guidelines for waste management from demolition, there is a determination of the amount of waste from the demolition of houses from the inspection of BOQ documents. The transport distance to the landfill/recycling is 40 kilometers by 6-wheel trucks [33].

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Table 5 The costs in the end of life stage

Description of cost	Cost (Baht/ m^2)	Total cost (365 m^2)	Remark
Demolition (include labor, energy, transport)	310	113,150.00	Interview with 5 companies of building and house demolition contractors and average demolition costs.
Total cost		**113,150.00**	

Suggestions for the cost of the demolition process include that the demolition company will sell the demolition waste to the scrap metal purchase company for recycling. In this case, the study did not consider the cost of waste management and assumed that all demolition waste was directed to the demolition waste management process. So, except for scrap metal from demolition, the demolition company will be sold to scrap metal purchase companies for recycling. The amount received is 131,054.07 baht, thus becoming the revenue of the demolition company and cannot be deducted from the cost of the demolition process.

From calculating the cost over the life cycle of a detached house over a period of 50 years. It was found that the construction stage amounted to 3,585,631.45 baht, the use stage cost 1,207,059.48 baht, and the end of life stage demolition cost 113,150.00 baht, as shown in Table 6, and the proportion of costs in each step of the detached house in Figure 5.

Table 6 The summary life cycle costing of the detached house over lifetime 50 years

Life cycle stage		Life time cost (Baht)
Construction	Materials	2,719,873.55
	Labor	797,877.59
	Transport	23,157.40
	Construction facility fee	44,722.91
	Construction total	3,585,631.45
Use	Electricity	1,001,955.27
	Energy cost (Household gas)	10,024.57
	Water supply	82,430.51
	Maintenance, repairing and replacement	112,649.13
	Use total	1,207,059.48
End of life	Demolition	113,150.00
	Total	**4,905,840.93**

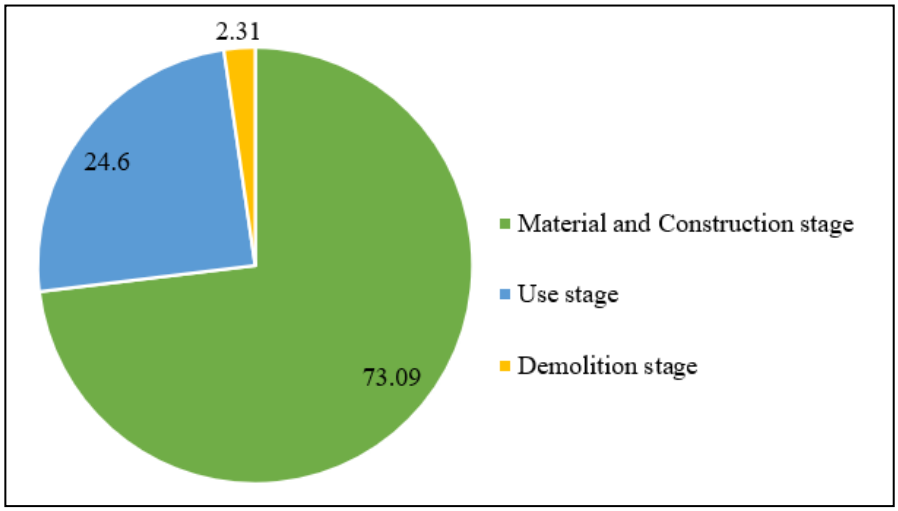

Figure 5: The proportion of total life cycle cost (3 stages) of a detached house over 50 years.

5. Conclusions

The detached house case study's overall life cycle cost analysis was compiled from the De De Rak Nam 3 project model, and Microsoft Excel was used as a tool to assess the LCC of the detached house, including materials and construction stage, use stage, and demolition stage. These future costs are converted to present value (PV) in cash flows. It was found that the cost over the life of 50 years at a discount rate of 6% per year amounted to 4,905,840.93 Baht. Subsequently, when considering the main cost of the materials and construction stage accounted for 73.09%, mainly because the value of construction materials at present tends to increase to 8.9% in all product categories. Specifically, steel, cement, and concrete products [29], are the primary building materials. The causes are a recovery in construction demand, government support measures requiring the use of domestically produced construction materials, an increase in the cost of imported raw materials such as scrap and billets in line with the direction of world market prices, and rising electricity and fuel costs [16]. The approach to controlling the cost of this part is to modify the traditional house construction method to construct a modular house with a prefabricated house structure [10]. In terms of quality, it saves costs, shortens construction time, and reduces environmental pollution. Next, the use stage costs 24.6%, with the main cost of the implementation being 20.42% electricity, 1.68% water, 2.29% maintenance, and 0.20% cooking gas. Therefore, the main reason for the high cost is the long service time of the electrical appliances. The Ft adjustment is about 5% higher by the Metropolitan Electricity Authority [23]. By the way, the solution should be to improve the switch to using solar energy or solar cells to replace the primary electricity source. Installing a solar power generation system with an area of 20-40 square meters, with the total cost of panels and accessories around 350,000 - 470,000 baht. The investment can be returned within 7-9 years. The important thing that should take into account is the position and orientation of the house along with local conditions and environments, such as the context of the house's location [32]. Electrical equipment with a service life of more than 10 years should be replaced because of its low efficiency [14], and consumers should conserve energy, fuel, and water [26]. Lastly, the demolition stage accounted for 2.31%, which was the lowest cost ratio. Therefore, the cost of this demolition is the responsibility of the person who owns the detached house. The demolition contractors are the managers of the waste and scrap that occurs [30] in the following ways: scrap sorting, demolition, reuse, recycling, as well as transportation for scrap sale and disposal. Hence, this detached house cost analysis has parameters for cost calculations depending on the economic situation. This study can be applied to calculate the life cycle cost of other residential buildings for the benefit of those interested in making decisions in building construction project planning.

6. Limitations and Future study

Based on the literature review for calculating total cost in most case studies. It was found that there were some limitations to some variables, namely construction cost, operating costs, maintenance cost, and demolition cost, which were included in the total cost analysis. But this does not include the cost of decorating the house. In addition, most of the LCC calculations are made for residential homes and office buildings. There are only details of construction materials, electricity, water, energy, and transportation costs for each life cycle stage [6][7][22]. Therefore, the LCC analysis of case studies considers the detached houses in Bangkok, which can be studied further in the next work in the section on cost comparison of more than one building construction project to investment, calculating the Saving-to-Investment Ratio (SIR), and the payback period analysis.

Acknowledgement: The authors would also like to give special thanks to Ratchaneewan Sanlad from Rajamangala University of Technology, Lanna, as well as assistance from Wichan Tepi at Placknu Subdistrict Administrative Organization, Songkhla Province, for providing data.

Funding: The authors would like to thank for the support from the Technology Development Agency and Sirindhorn International Institute of Technology, Thammasat University, TAIST-Tokyo Tech Scholarship funded by the National Science and Technology Development Agency (NSTDA) in Thailand and the National Metal and Materials Technology Center (MTEC) that supported this research.

Conflict of Interest: The authors declare no conflict of interest.

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 ISBN: 978-86-87043-85-5

Preparing for Hurricanes: An Evaluation of Disaster Preparedness in East Coast Schools

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Section 1.1 Introduction: Hurricane Katrina

In 2005, Hurricane Katrina made landfall in New Orleans. With winds gusting over 125 miles per hour, it was one of the most devastating hurricanes in US history. The flood protection, telecommunications, and surface transportation systems were completely destroyed, and the levees, floodwalls and natural ridges designed to keep out flood water ironically ended up trapping it inside the city for 53 days.[1] Three weeks later, Hurricane Rita struck New Orleans a second time, and the combined damage from both storms led to over 1,800 deaths and $200 billion in property damage.[2]

Despite all of the destruction and tragedy that the region underwent, there is still hope in this story: people volunteered to come in and clean up parks, streets, and roads under grass-roots organizations such as The Katrina Krewe; the Musicians Village worked to provide permanent housing for musicians; Federal Emergency Management Agency (FEMA) offered temporary housing to 64,150 households through their "Katrina Cottages;" and the Regional Transit Authority utilized the remaining streetcars and buses to facilitate city mobilization.[3]

Katrina is a story about people coming together to build themselves up.[4] We can learn from this both in terms of how to prepare for a disaster and the resilience needed to respond.

Section 1.2 Why We Need Disaster Preparedness in United States East Coast Schools

We can't ignore it anymore: climate change is worsening each year, increasing the number of natural disasters. According to The Washington Post, "Nearly 1 in 3 Americans live in a county hit by a weather disaster in the past three months."[5] In fact, the National Oceanic and Atmospheric Administration reported that this year (2022) marks the 7th consecutive above-normal hurricane season.[6]

Christina Caron of The New York Times notes that these disasters often cause incredible damage: at least 10 one billion-dollar disasters occurred every year from 2015-2020.[7] A look at the most destructive hurricanes in the United State's recent past will only reinforce this sentiment. The five most costly hurricanes in descending order of expensiveness were Hurricane Katrina (2005 - $186.3 billion), Hurricane Harvey (2017 - $148.8 billion), Hurricane Maria (2017 - $107.1 billion), Hurricane Sandy (2012 - $81.9 billion), and Hurricane Ida (2021 -

[1]"Urban Resilience in Post-Katrina/Rita New Orleans - LSU," accessed July 29, 2022, http://evaccenter.lsu.edu/pub/amdphk.pdf. [2]"Louisiana Recovery Authority," Louisiana Recovery Authority, accessed July 28, 2022, http://www.louisianarecoveryauthority.org/. [3]"Hurricane Katrina," Urban Planning of New Orleans, accessed July 28, 2022, https://neworleansusp100.weebly.com/hurricane-katrina.html.

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$78.7 billion).[8] Though many of these hurricanes haven't matched the terror Katrina instilled, they have been starting to appear more frequently (Harvey, Maria, and Ida all occurred in the past 5 years).[9]

Unfortunately, many of the districts most affected by these disasters, particularly those along the East Coast, also contain the most students. According to ABC News, "more than half of the nation's public school districts are located in counties that were subject to major disasters from 2017-2019 and comprise more than two-thirds of the nation's students."[10] What's more, the Atlantic Hurricane Season runs from June 1 to November 30 and peaks in early fall, so many schools may be impacted just as they are reacclimating to the school environment.[11]

Children in schools are a particularly susceptible group to natural disasters because they are separated from their parents and are not yet ready to take care of themselves. Children with disabilities, medical needs, or limited English proficiency can add to the challenges of responding in critical situations. With climate change rising, severe disasters already striking the US in increasing frequency, and a lack of physical infrastructure or preparedness, the situation looks bleak. In fact, a National Report Card discovered that only 29 states were adequately prepared for meeting the standards of safety in the event of a natural disaster.[12] Nevertheless, with proper resource investment and allocation, East Coast schools can turn the tide and make a stand to protect the future of tomorrow.

Section 2 Federal Government

The two primary disaster preparedness federal agencies, FEMA and the Department of Education (DOE), each have their own guides on emergency preparedness.[13] Both guides tackle the issue in general terms, highlighting the basic steps that schools can take but not offering much specificity beyond that.[14] As such, analyzing contributions on the state and district level will be more useful.

It is worth noting that the DOE runs the Disaster Recovery Unit, a committee that financially supports school communities and helps coordinate agencies. However, as this group focuses on the response effort in particular, it fails to address the core issue behind the lack of school safety: inadequate preparation.[15]

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 ISBN: 978-86-87043-85-5

Section 3.1 A Table Evaluating States' Preparedness Levels

	Disaster Preparedness Guide	Drills	Additional Features	Areas to Improve	Overall Grade
Louisiana	Not Available	Not Available	Issued The Protect Louisiana Schools: Hurricane Preparedness Commission Mandates an Emergency Preparedness and Recovery Point of Contact Coordinates partnerships with school buses to facilitate emergency evacuations	Guide is not directly accessible online and only available in physical copies at Red Cross	Prepared
Florida	Very Prepared	Hurricanes, tornadoes, and severe storms	Includes specialized state plans that tailors the federal government's plans to the state specifically Wrote The State of Florida 2020 Comprehensive Emergency Management Plan	Clarify what each drill includes	Very Prepared
North Carolina	Prepared	Guide has advice on how to respond to tornadoes and thunderstorms	Places a special emphasis on providing access to free meals during disasters Works closely with Emergency Alert Stations	N/A	Prepared
Virginia	Very Prepared	Tornado Drill and Earthquake Drill	Administers a climate survey for public schools in Virginia Created the School Crisis, Emergency Management and Medical Emergency Response Plan that helps schools prepare for earthquakes, dam failure, floods, lightning, and tornados. Wrote The Virginia Educator's Guide for Planning and Conducting School Emergency Drills	N/A	Very Prepared
Texas	Prepared	Shelter for Severe Weather Drill	Coordinates with NOAA Weather Radio Created theTexas School Safety Center, an official university-level research center at Texas State University that places a primary emphasis on	N/A	Prepared

			Mandatory Drills for Schools, Guidelines, and an Operations Plan.[16] Created a Hurricane Quick Reference Guide by the Texas School Safety Center and Texas Education Agency.[17]		
New York	Not Available	Not Available	N/A	Create a guide and emergency preparednes s drills	Unprepar ed
Maryland	Unprepar ed	Shelter for Severe Weather Drill	N/A	Develop better guide to tailor to Maryland	Unprepar ed

Section 3.2 Prepared State Governments

For the most part, many states have sufficient emergency preparedness guides that outline important steps school districts need to take and consider nearby geography. The information below includes other ways that state governments are taking initiative and promoting preparedness.

Louisiana

Louisiana requires schools to practice crisis management and have a response plan ready in the event of a disaster. The state helps schools create their own Emergency Operations Plans through development workshops, and provides expert review and technical assistance workshops for those that already have. “The review process will identify strengths and recommend areas of improvement in the EOP,” says the Louisiana DOE.[18]

Louisiana also encourages schools to put out an Emergency Preparedness and Recovery Point of Contact who will update the school’s emergency preparedness information and be the reference point in case of a natural disaster. Furthermore, Louisiana has a guide called the 2020 Louisiana Student Transportation Operational Procedures that coordinates partnerships with school buses to facilitate emergency evacuations.

Recently, the state launched The Protect Louisiana Schools: Hurricane Preparedness Commission to help fortify school infrastructure and respond to hurricanes in the Baton Rouge area. "Many coastal public schools have been devastated from the repeated barrage of high winds, torrential rain, and flash floods, resulting in billions of dollars in damages – roofs torn off,

[16]“TXSSC,” Home | Texas School Safety Center, accessed July 28, 2022, https://txssc.txstate.edu/. [17]“Hurricane Quick Reference Guide for School Administrators August 2020,” accessed July 29, 2022, https://tea.texas.gov/sites/default/files/EOP-Hurricane-Quick-Reference.pdf.
[18]“Dot Emergency Preparedness, Response, and Recovery Information,” U.S. Department of Transportation, accessed July 28, 2022, https://www.transportation.gov/emergency.

hallways flooded, and walls collapsed," said State Superintendent of Education Dr. Cade Brumley.[19]

Florida

Florida contains many foundational pieces to a good school preparedness guide. The State of Florida 2020 Comprehensive Emergency Management Plan describes how Florida is susceptible to many hazards such as floods, tropical cyclones, tornados, and wildfires, information that can prove very useful when preparing for the future.[20] The guide notes that Florida's shipping and tourism industries are crucial, and that most people live along the coast and speak a variety of languages.

North Carolina

North Carolina prioritizes the importance of food security in the event of disasters. During Hurricane Irma, when many families evacuated to North Carolina, the state government tried to provide free meals to displaced individuals by working with the State's Homeless Liaisons and Coordinators.[21] The state particularly made an effort to connect with students in need by working with school principals to identify homeless students and make the process as non stressful as possible.

Virginia

Virginia offers a climate survey that contains data from across the nearly 2,000 public schools in the state with 100% participation. The survey offers Virginia's planners more information about how to better equip its schools and make safety improvements, specifically targeting the schools that need drastic improvements.[22]

The Virginia Educator's Guide for Planning and Conducting School Emergency Drills lists various weather-related exercises that schools must practice.[23] One of these is the Tornado drill, under which schools must call emergency contacts, spread word to those outside school buildings, move students to designated areas (the guide recommends interior, underground areas on the north east side if possible), and telling all students to "duck and cover," a formation attained by crouching down and covering one's head with their arms. Another drill they mandate is the Earthquake drill, which includes important procedures such as utilizing the public announcement system to announce when shaking has begun and stopped, practicing similar actions to the Tornado drill by covering one's body, and moving students into the middle of an open field where there is nothing that could fall on top of them.

[19]"Louisiana DOE Launches Hurricane Preparedness Commission," Louisiana Believes - Louisiana DOE, accessed July 28, 2022, https://www.louisianabelieves.com/newsroom/news-releases/release/2022/02/01/louisiana-department-of-education-launches-hurric ane-preparedness-commission.
[20]Solodev, "Critical Incident/Emergency Planning for Schools," Florida DOE, accessed July 28, 2022, https://www.fldoe.org/finance/emergency-management/critical-incident-emergency-planning-f.stml. [21]"To: School Nutrition Administrators - Dpi.nc.gov," accessed July 29, 2022, https://www.dpi.nc.gov/media/12843/download?attachment.
[22]"Model Crisis, Emergency Management and Medical Response Plan ... - Virginia," accessed July 29, 2022, https://www.dcjs.virginia.gov/sites/dcjs.virginia.gov/files/publications/law-enforcement/school-crisis-emergency-management-and-me dical-emergency-response-plan-quick-guide_0.pdf.
[23]"Virginia Department of Criminal Justice Services Improving and Promoting Public Safety in the Commonwealth," Virginia Department of Criminal Justice Services | Improving and promoting public safety in the Commonwealth, accessed July 28, 2022, http://dcjs.virginia.gov/.

Texas

Texas practices a Shelter for Severe Weather Drill, an exercise that involves quickly moving students and staff indoors into more secure locations, oftentimes "to rooms without windows on the lowest floor possible or to a weather shelter."[24] Moreover, Texas has implemented specific stations in the NOAA Weather Radio informing residents about "warnings, watches, forecasts, and other hazard information 24 hours a day."[25]

Section 3.3 Unprepared State Governments New

York

New York State contains no comprehensive disaster preparedness plan for weather related incidents.

Maryland

Maryland practices a Shelter for Severe weather drill similar to Texas, a vital exercise that can help with school procedures in the event of an actual disaster.[26]

Section 4.1 Prepared Districts Broward

County, Florida

Broward stands out as a county that is doing everything right to prepare its schools for a potential disaster. Though just a district, they have a holistic guide that hones in on storms specifically, describing pre-storm procedures (transportation, physical plant operations, information and technology, facilities and construction management, innovative learning for media centers), during storm procedures, and post-storm procedures. It contains emergency contacts, important protocols, and more information about Broward's topography.[27]

Miami Dade, Florida

Miami Dade's guide includes a portion on natural disasters, which specifically analyzes the effects of hurricanes, earthquakes, tornados, and floods. The guide investigates how to help students readjust after coping with a natural disaster from both the teachers' perspective and the parents' perspective.[28]

[24]"TXSSC," Training, Drilling, and Exercising Toolkit | Texas School Safety Center, accessed July 28, 2022, https://txssc.txstate.edu/tools/tde-toolkit/drill-requirements.
[25]"Legal Services," Texas Association of School Boards, accessed July 28, 2022, https://www.tasb.org/services/legal-services.aspx/. [26]"Emergency Planning Guidelines for Local School Systems and Schools," accessed July 29, 2022, https://www.marylandpublicschools.org/about/Documents/DSFSS/SSSP/EPSS/EmergencyPlanningGuidelines2017.pdf.
[27]"Browardschools.com," accessed July 29, 2022, https://www.browardschools.com/cms/lib/FL01803656/Centricity/domain/23291/pdf/Emergency_Preparedness_Manual.pdf. [28]"Miami-Dade County Public Schools Crisis Management Resource Manual," accessed July 29, 2022, https://api.dadeschools.net/WMSFiles/94/pdfs/Crisis_Manual0726126(Final).pdf.

Section 4.2 Unprepared Districts Houston,

Texas

Houston does not have a school guide. It contains tips for families to endure natural disasters, whether through making a plan, building a kit, staying informed, or knowing the neighbors well, but it still lacks something for school administrators to use.[29]

Section 5 Evaluation

Section 5.1 The Guide - What School Administrators Should Do Pre-

Storm Protocol

The first component of pre-storm protocol is for staff to be well-educated. It's important to know terms like "Watch," which signifies that hurricanes are possible in an area, and "Warning," which indicates that hurricanes are expected in the area. Moreover, it's crucial to constantly check in on forecasts such as the Hazardous Weather Outlooks, which projects the weather for the next seven days, or to alternatively use an NOAA Weather Radio that gives even more advanced notice of any possible weather conditions.[30]

School bus drivers should also be well informed about what to do in the event of severe weather while transporting students. Drivers should participate in practice sessions and know of shelters along school routes in case they're caught in a storm. They're also encouraged to take Skywarn severe weather spotter training classes to detect warning signals.[31]

Another important element is having a plan ready for when a disaster does strike. The plan should include the physical layout of schools and designate shelter areas under the guidance of school officials or building engineers, preferably in jagged hallways or small rooms such as bathrooms or offices on the interior on the lowest floor.[32] Shelters should be readily accessible (under 3 minutes travel time) and accommodate all students regardless of the time of day. Some helpful planning questions include how to protect expensive systems such as heating, ventilation, and air conditioning systems, and how to transmit information among administrators and facilities teams.

It's also important to develop a method that notifies everyone about an impending natural disaster. A school speaker system is one effective way to transfer this information, though it's important to have a backup resource such as an air horn or megaphone in case electricity is lost.

During Storm Protocol

During the storm, it is important to use radios for staff to communicate and to have storm spotters monitor weather information. Staying away from windows and removing possible moving objects can also help with safety. For students actively on a bus, they should go into a ditch, and the bus should be moved far away so that it doesn't get fall on top of them.

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[29]"Make a Plan Build a Kit Stay Informed Know Your Neighbors," accessed July 29, 2022, https://www.readyhoustontx.gov/wp-content/uploads/COH-trifold-broch-English.pdf.

[30]NOAA US Department of Commerce, "NOAA Weather Radio," National Weather Service (NOAA's National Weather Service, June 2, 2016), https://www.weather.gov/grb/nwr.

[31]NOAA US Department of Commerce. "NWS Green Bay Skywarn Spotter Home." National Weather Service (NOAA's National Weather Service, April 4, 2022), https://www.weather.gov/grb/skywarn.

[32] Daisy Kincaid. "Preparing Schools for Hurricane Season."

 ISBN: 978-86-87043-85-5

Post-Storm Protocol

After the storm has hit, the building should be assessed for damage. Once clear, students can leave the shelters or evacuate to safer areas. Similar to the signal that alerts students of a natural disaster, there should be an "all clear" message at the end that signals that everyone can return to their original rooms. In the aftermath, conducting a survey can help improve the current school preparedness plan.

Section 5.2 National and Local Inventory and Physical Infrastructure Investment

It's important to keep track of data across all levels. An important first step is a census funded at the national level: government representatives visiting every school in the country can create a comprehensive inventory. Checking vehicles, machinery, heating and cooling equipment, lighting, and security systems will help assess what kinds of support schools need. Using this information, we should then invest the necessary resources into renovating and maintaining schools. Doing so has an added benefit: discussing these renovations with students can serve as an opportunity to teach them about the consequences of climate change, which may inspire them to work toward protecting the environment. Keeping track of inventory can also speed up the process for repairs and replacements after a hurricane, whether it be losses, insurance claims, or disaster aid.

Section 5.3 Student Education

Another vital aspect of school preparedness is to make sure that the students themselves are well-informed. This can be accomplished through school drills, interactive guides, or school assembly meetings. Owlie Skywarn's Weather Book is a children's guide created by the American Red Cross, US Department of Commerce, US Department of Homeland Security, and NOAA. The brief and to the point guide picks interesting information about hurricanes, such as how the air around the Earth weighs over five quadrillion tons, but also critical information about listening to instructions when told to do so and going inland. The guide has information about pre-storm and during storm operations and a quiz for kids to test themselves at the end.[33] Similarly, the Community Education Services of the Children's Television Workshop produced a national public education program on natural disasters.
Recently, they released a fire program to help educate preschoolers through songs, skits, and other teaching techniques.

Section 5.4 Crisis Leadership

Crisis leadership is another vital part of school preparedness. Though school leaders, primarily school principals, may not be able to prevent natural disasters, they can help keep everyone calm by demonstrating leadership qualities and effectively communicating. This task can be quite daunting as leaders have to think on the spot and make timely decisions, but they can have a huge impact on the school community.

To be an effective crisis leader, one needs to be dispositional, relational, and situational. Dispositional consists of having a strong background with many experiences, values, and leadership skills. Relational includes being able to unify and galvanize the troops to one holistic body. Situational involves properly assessing certain situations and responding to them.[34]

[33]"National Weather Service," accessed July 29, 2022, https://www.weather.gov/media/owlie/owlie-hurricane.pdf.

[34] Grasser, Kara. 2022. Sensemaking and crisis communication: How school leaders communicate in times of crisis. Ph.D. diss., The George Washington University,

 ISBN: 978-86-87043-85-5

Section 5.5 Mental Health Program

When a natural disaster is declared, FEMA works with the National Institute for Mental Health (NIMH), an agency of the US Public Health Service, to provide valuable mental health support. This aid can consist of up to eleven months of crisis counseling for disaster victims. Due to the difficulty of providing one-on-one counseling, FEMA and the American Red Cross have been offering accessible mental health education guides for those who need them.

Having a good mental health program in advance is a very vital part of the recovery process. When dealing with victims of a natural disaster, it is important for disaster workers to provide outreach and avoid terms such as "mental illness." Oftentimes, community mental health centers are the best sources for mental support as they are familiar with local community members and the different mental health resources available to them.

Section 6 Conclusion

To sum, we need to do more to increase school resiliency against hurricanes and other weather-related events. Preparations for natural disasters will obviously be costly, and some might argue that this focus on school preparedness should really be geared towards climate change. Nevertheless, it is inevitable that climate change will persist for the next few decades, and in that span of time, many students could be vulnerable to climate change's side effects.

If we want schools to be ready for future disasters, it is imperative that we start now. The US has always committed to protecting its students. What does this commitment mean if the US does not take the steps necessary to protect students within the walls of its schools?

https://www.proquest.com/dissertations-theses/sensemaking-crisis-communication-how-school/docview/2673544246/se-2 (accessed July 13, 2022).

SDConference Proceedings 2022 ISBN: 978-86-87043-85-5

Role of financial sector towards achieving sustainable development goals in Bangladesh

Md. Touhidul Alam Khan

Abstract

Growth and sustainable development are both dependent on the health of the financial sector. The growth of the financial industry and the mobilization of resources from it can serve as a driving force for Bangladesh to attain the SDGs. The financial sector is a powerful tool for advancing Bangladesh's aims for sustainable development. In order to guarantee a greater standard of living, better education and skill development, faster poverty reduction and job creation, and the transformation of the economy into a middle-income status, accelerated financial growth has been proposed as a crucial development strategy. Examples of such ideas include the notion that aid and financial support are significant and required for Bangladesh, a developing nation, and that the key to utilizing private financing for development is to use public development finance. Worse investment and saving rates, lower human resource quality, lower total factor productivity, and rising land constraints are the main obstacles facing Bangladesh's financial sector in achieving the SDGs. Development in the financial sector is necessary for growth, and growth is necessary for sustainable development. The growth of the financial sector and the mobilization of resources from it may act as a stimulus for achieving the SDGs, so that enhanced resource mobilization from the banking, non-bank financial, semi-formal, and informal sectors may come forward to contribute in development growth of the country. Bangladesh is hence far more optimistic and ambitious about SDGs. The experience of implementing the Millennium Development Goals (MDGs) and the lessons discovered through them will be beneficial for implementing the Sustainable Development Goals.

Keywords: Sustainable Development Goals (SDGs), Millennium Development Goals (MDGs), Financial Institutiins (FIs), Environmental, Social and Corporate Governance (ESG), Bangladesh Bank (BB), Global Alliance for Banking on Values (GABV).

 ISBN: 978-86-87043-85-5

Introduction

Bangladesh, a country with a high population density, has achieved this accomplishment thanks to the political leadership's passion and commitment to the MDGs, especially at the highest levels of the current Government. The Honorable Prime Minister of Bangladesh has received particular recognition from foreign organizations by being given awards for achieving certain MDG milestones. However, there are some areas that require more attention, including creating jobs, increasing the number of skilled health professionals present at childbirth, expanding the area covered by forests, utilizing information and communication technology, raising rates of adult literacy and primary school completion, and creating jobs for women that pay a living wage, enhanced water and sanitation management, universal access to modern, sustainable energy, sustainable industrialization and innovation, action against deforestation, guaranteeing the sustainable use of marine resources, universal access to justice, and strengthening the international partnership for sustainable development. Financial help is necessary in order to successfully transform the entire target area. Here, the financial industry in our country may significantly contribute to their sustainable development. Green and sustainable initiatives and frameworks are essential for enhancing the sustainability of future development. The larger sustainable development agenda of a nation like Bangladesh includes the formation of sustainable frameworks very extensively. Because of their ability to influence production, business, and other economic activities through their financing activities, banks and financial institutions (FIs) have a special position in the economy. As a result, they have an impact on environmental risk management in the real economy as well as sustainable growth. These organizations have a significant impact on speeding up the transition to a clean environment. These organizations, for example, could establish a "go green" policy and push their client companies to do the same. In long-term, this strategy is anticipated to benefit businesses by lowering costs and encouraging access to new markets. All financial institutions should monitor the carbon footprint of their clients or projects to ensure overall sustainability in order to advance their own interests. Mentionable that for the first time, Bangladesh Bank (BB) has defined “Sustainable Finance” for Banks & FIs.

 ISBN: 978-86-87043-85-5

Literature review

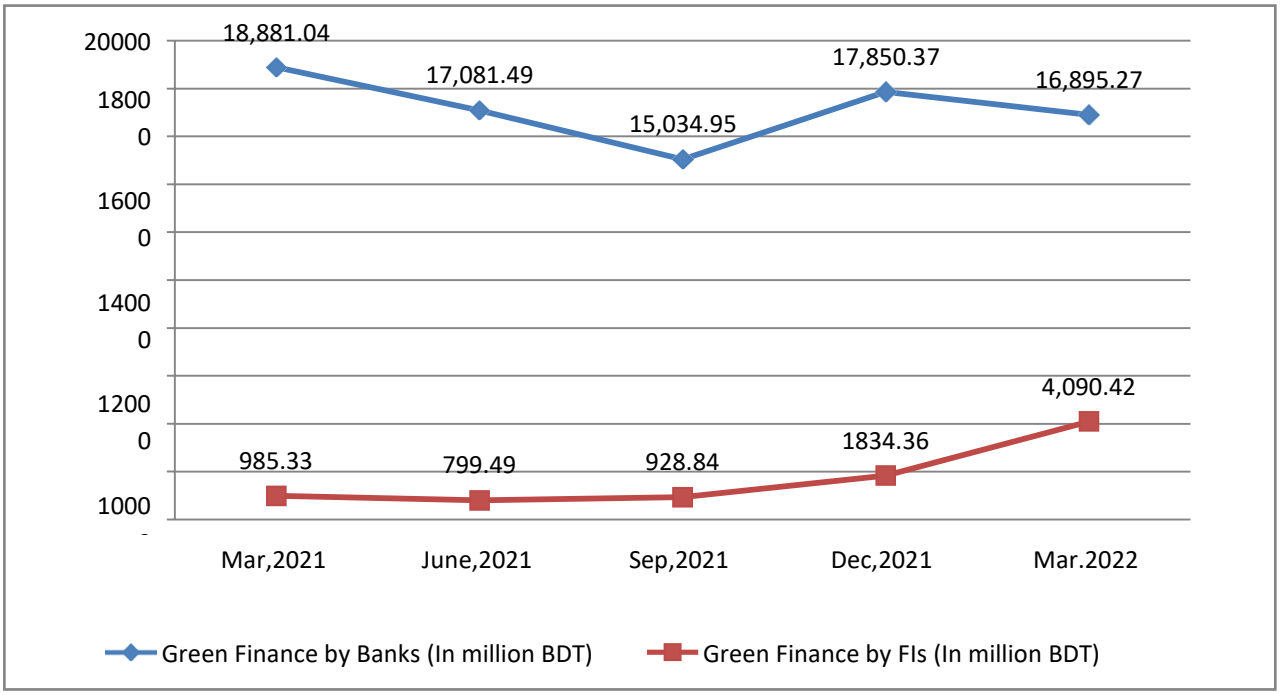
Scholtens (2006) emphasizes sustainable finance as a driver of sustainability, especially through socially responsible investments (Waring & Edwards, 2008). In the last decades many institutions point out the need for financial institutions to integrate environmental, social and corporate governance factors (ESG factors) into the decision-making process to mitigate ESG risk. According to Pisano etal. (2012), a vast gap remains between sustainable development and the actions of most financial markets. Vandeke rckhove and Leys (2012) identify especially issues that must be revised to cover the gap between sustainable development and finance among them: better indicators for analyzing sustainable development goals (SDGs) and recommendations for sustainable financing strategies and investments (Ziolo etal., 2019). Sustainable finance is developing concept and a kind of response to financial markets to sustainable development challenges related to its financing. Gerster (2011) points out that sustainable finance is defined as a kind of financing addressing environmental, social, and governance (ESG) impacts of financial services. Schoenmaker (2017) propose framework for Sustainable Finance based on sustainable finance models (SFM). Schoenmaker (2017) distinguishes.

Role of Financial Sector for Sustainable Development Goals (SDGs) in Bangladesh

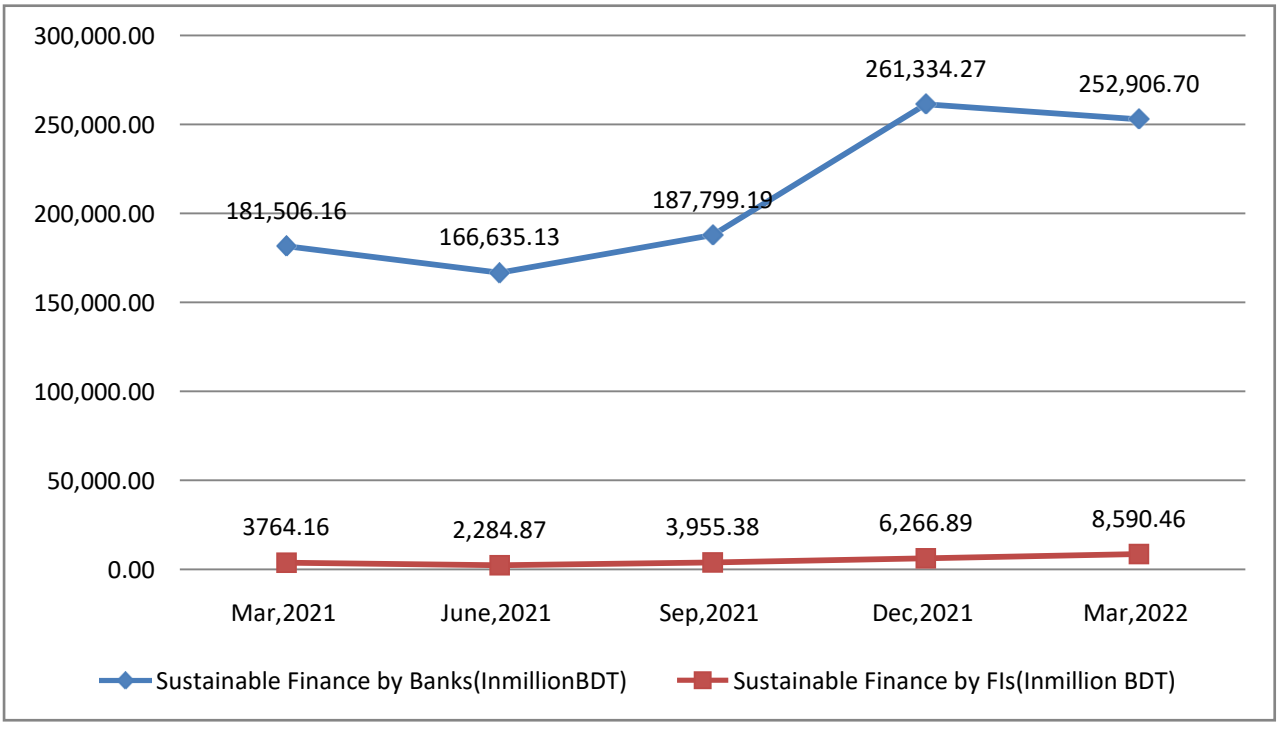
The financial sector is a powerful tool for advancing Bangladesh's aims for sustainable development. In order to guarantee a greater standard of living, better education and skill development, faster poverty reduction and job creation, and the transformation of the economy into a middle-income status, accelerated financial growth has been proposed as a required development strategy. These ideas, for instance, include the notion that aid, and financial support are essential for Bangladesh, a developing nation, and that the SDGs can only be achieved by leveraging public development finance to catalyze private finance. Worse investment and saving rates, lower human resource quality, lower total factor productivity, and rising land constraints are the main obstacles facing Bangladesh's financial sector in achieving the SDGs. Development in the financial sector is necessary for growth, and growth is necessary for sustainable development. The growth of the financial sector and the mobilization of resources from it may act as a stimulus for achieving the SDGs, so that enhanced resource mobilization from the banking, non-bank financial, semi-formal, and informal sectors take initiatives for the development growth. We shall establish a connection between the financial sector and the objectives of sustainable development in this study.

 ISBN: 978-86-87043-85-5

Quarterly Trend of Green Finance & Sustainable Finance



Source: Bangladesh Bank



Source: Bangladesh Bank

 ISBN: 978-86-87043-85-5

In January-March 2022 period contribution to green finance is BDT 20,985.69 million which is BDT 1300.96 million more than October-December 2021 period. In contrary, in January-March 2022 period contribution to sustainable finance is BDT 2,61,497.16 million.

Refinance scheme for environment friendly products/initiatives

In order to increase the financing options for environmentally friendly products like solar energy, biogas plants, and effluent treatment plants, Bangladesh Bank (BB) established a revolving refinance scheme for solar energy, biogas plants, and effluent treatment plants (ETP) in 2009. With the need for financing of environmentally friendly products and projects on the rise, the fund's size has expanded from BDT 2.00 billion to BDT 4.00 billion. The number of products has increased to 55 under 9 categories. Since the fund's inception, a total of BDT 6,215.92 million has been disbursed as a refinancing facility till March 31, 2022. The disbursement scenario of this scheme during January-March, 2022 quarter is furnished below:

Figure: category/Product-wise Disbursement

SL. No	Sub-category/Product	BDTinmillion
1	InstallationofEnergyAuditorCertifiedmachineriesincludingboilerin industries	34.50
2	Environment Friendly/Brick Kiln Efficiency improvement Project	55.00
3	Production of Vermi compost	0.19
4	Integrated Cow Rearing and Setting up of Bio-gas Plant	0.45
5	Net Metering Roof top Solar System	9.00
6	Solar Home System	0.76
	Total Disbursement	**99.90**

Source: Bangladesh Bank

Sustainable alliances in the financial services sector

The 2030 Agenda offers financial institutions the chance to show how they uphold their social responsibility and satisfy stakeholders, thereby legitimizing their existence. The agenda

 ISBN: 978-86-87043-85-5

also offers a business opportunity, too. To Financial institutions must make positive externalities from their operations that benefit society. Offer customers sustainable products by changing their business model. This Reorientation, in turn, calls for more open communication with stakeholders and internal changes to the business model. Sustainability reporting is a highly useful tool for this suitable channel. The increasing emergence of coalitions among organizations that share a sustainable business model has verified the ongoing transformation of financial institutions' business models a commercial strategy, like that of the Global Alliance for Banking on Values (GABV). Founded in 2009, this network seeks “to change the banking system so that it is more transparent, supports economic, social and environmental sustainability, and is composed of a diverse range of banking institutions serving the real economy”. To adhere to the GABV, financial institutions must adhere to five basic principles: (i) Social and environmental impact and sustainability must be placed at the heart of the business model; (ii) Operations must be focused on communities, serving the real economy, enabling new business models and meeting real needs; (iii) Long-term relationships should be established with clients, obtaining a direct understanding of their economic activities and of the risks involved; (iv) Operations should be long-term, self-sustaining and resilient to outside disruptions; (v) Governance should be transparent and inclusive.

Financial institutions’ promotion of sustainable banking is also apparent in their ‘Green Loan/Investment Principles’, which were developed by leading institutions in the green /investment market to promote the development and integrity of this product. These principles create framework of market standards and guidelines, providing a consistent methodology that can be used across the green loan market, while maintaining loan flexibility and preserving market integrity. The Principles are characterized by four key components: (i) Use of proceeds (the use of the loan amount must offer clear environmental benefit); (ii) Process for project evaluation and selection (the borrower must clearly communicate to the banks the environmental sustainability objectives envisaged); (iii) Management of proceeds (the amount of a green loan must be stipulated in a specific account or it must be subject to appropriate supervision in a way that maintains transparency and promotes product integrity); (iv) Reporting (the borrower must prepare information, which must be current and available, on the annual use made of the funds provided).

The Principles for Responsible Banking, promoted by the UN Environment Programme Finance Initiative, are a framework for a sustainable banking system and help the

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industry demonstrate how it makes a positive contribution to society. These Principles embed sustainability at the strategic, portfolio and transactional levels, across all business areas and cover issues related to business strategy, clients and customers, stakeholders, governance and culture and transparency and accountability.
The above initiatives to promote responsible and sustainable banking build upon the closely related Equator Principles, a risk management framework established in 2003. A recent publication in this respect supported the objectives of the '2015 Paris Agreement' and emphasised that the effective application of the Principles would contribute to delivering the objectives and outcomes of the SDGs. Finally, the UN Global Compact is a global movement of sustainable companies and stakeholders that do business responsibly by aligning their strategies and operations with principles in the areas of human rights, labour, environment and anticorruption concerns and that take strategic actions to advance broader societal goals, such as the SDGs, with an emphasis on collaboration and innovation. These initiatives underline the part that financial institutions must play in advancing the 2030 Agenda, notably by incorporating environmental and social factors into their project financing and other bank lending products and services. Under with this knowledge, environmental credit risk management is developing (ECRM), the process of evaluating credit involves using environmental risk assessment processes. Regarded as a crucial component of banks' risk management strategies.

Goal 1: End poverty in all its forms everywhere

Over one billion people still live on less than $1.25 per day, despite the fact that we have made enormous progress in eradicating poverty over the past 30 years. If we can't move the noodle on this one, we won't be able to accomplish our other worldwide objectives. By 2030, we must end extreme poverty and cut the number of people in poverty in half.

Goal 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture

Small farmers all across the world depend on their surroundings, but habitat loss, climate change, and political unrest are depleting their supplies. Aside from producing wholesome food, agriculture, forestry, and fisheries also promote thriving, healthy communities by producing jobs.

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Goal 3 Ensure healthy lives and promote well-being for all at all ages

Even though we live in the most technologically advanced era of science and medicine, millions of people still die every year from preventable causes like untreated sickness, drug and alcohol misuse, avoidable birth deformities, and avoidable industrial and traffic accidents. We must ensure that every person, child or adult, has access to the resources they require to live a long and healthy life. Where a person lives or how much money she has shouldn't ever prevent her from obtaining the medical attention she needs.

Goal 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all

More resources and regulations are required as the world's population increases to ensure that every student receives a quality eulachon. The world requires 2 million teachers, and a million additional classrooms will be built to ensure that all students have full access to a quality education. The first step to attaining sustainable development and eradicating poverty is quality education.

Goal 5: Achieve gender equality and empower all women and girls

Every civilization still has significant gender disparities. Many women still don't have access to essential services like health care, education, and jobs, and they frequently face violence and discrimination. The math is straightforward: counties with better equality have lower poverty, greater economic growth, and higher living standards. By removing obstacles to women's participation in economic, social, and political life, we may all have better possibilities.

Goal 6: Ensure availability and sustainable management of water and sanitation for all

More than half of all households have access to clean water at home, but as more people migrate into crowded cities, the number of people without appropriate sanitation (a safe toilet) is rising. Every year, illnesses brought on by tainted water claim more lives than all

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types of violence combined, including war. Millions of people's lives and health can be improved by placing a priority on having a clean wallet.

Goal 7: Ensure access to affordable, reliable, sustainable and modern energy for all

Not only is clean, renewable energy better for the environment, but 43 million individuals die annually. Every year from pollution caused by fire or harmful fuels used in domestic cook burners. These fatalities are absolutely avoidable, so we must ensure that everyone has access to renewable energy by 2030.

Goal 8: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all

Both the quantity and quality of jobs worldwide have been negatively impacted by the economic recession. The availability of jobs is essential for economic growth and more equitable income distribution for the 190 million unemployed. For civilizations to be secure and stable, economic development and chances for gainful employment are essential.

Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation

Developing nations are unable to maximize the use of their available natural resources and human labor without the proper infrastructure and technology. Innovation and research, which are essential for job creation, the eradication of poverty, gender equality, labor standards, and increased access to healthcare and education, are greatly aided by industry. We can advance inclusive and sustainable industrialization and technological advancement by working together.

Goal 10: Reduce inequality within and among countries

Without equal possibilities for all nations and their populations, we cannot live in a world that is fully developed. All of the sustainable development goals are based on equality. Together, we can encourage and enable all individuals to participate in social, economic, and political life, regardless of their ages, sexes, disabilities, ancestry, ethnicity, religion, economic status, or other characteristics.

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Goal 11: Make cities und human settlements inclusive, safe, resilient and sustainable

Nearly 60% of the world's population will reside in urban areas by 2030, with the majority of this urbanization taking place in developing nations. Rapid urbanization puts strain on fresh water supplies, sewage systems, the quality of life, and public health. The advantages of technology and society should be welcomed.

Goal 12: Ensure sustainable consumption and production patterns

Sustainable production and consumption are all about getting more done with fewer resources. By 2050, it is anticipated that there will be ten billion people in the world, further straining its limited resources. In order for everyone, including our grandkids, to enjoy a high standard of living with access to food, water, electricity, and other necessities, we must encourage sustainable lifestyles.

Goal 13: Take urgent action to combat climate change and its impacts

By burning a lot of fossil fuels over the past 150 years, the industrialized world has altered the balance of the planet's carbon cycle. Climate change has the potential to thwart other efforts toward sustainable development by altering weather patterns that threaten our food production and rising sea levels that will uproot coastal communities. In order to start tackling climate change before it is too late, we need to raise awareness and emphasize urgency to global leaders.

Goal 14: Conserve and sustainably use the oceans, seas, and marine resources for Sustainable development

Human actions like marine pollution, overfishing, and habitat degradation are endangering and destroying our oceans and seas. Nearly 200,000 species can be found in the oceans, which make up three-quarters of the surface of the planet. More than 3 billion people depend on the beauty of the marine and coastal biodiversity for their lives. If we move fast to maintain and safeguard our marine resources and habitats, we can stop and undo the harm we have done to the oceans around the world.

Goal 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss

 ISBN: 978-86-87043-85-5

Biodiversity is dwindling due to pressures from our expanding global population, urbanization, and climate change. The majority of developing nations rely on wild animal meat for food. In order to stop ecosystem imbalance, land degradation, and food insecurity, we must act to restore and maintain our planet's biodiversity.

Goal 16: Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels

Only with more inclusive and peaceful societies can we hope for a more fair and sustainable world. Therefore, we must lessen crime, violence, and exploitation. The illicit trade in weapons and goods must stop. The public institutions on which we all rely must be efficient, open, and responsible.

Goal 17: Strengthen the means of implementation and revitalize the global partnership for sustainable development

These 17 objectives' accomplishment is not some idealistic fantasy. Global objectives have been proven to be effective in the past, so we are extending the scope of the new goals to address the underlying causes of poverty. We have the resources and expertise to win this battle, but only if everyone realizes how close we are.

Sustainability and risk management in the financial services sector:
Many financial institutions are changing their operations to make them more sustainable in response to mounting pressure from regulators and customers. The markets frequently believe that financial firms have a significant obligation to encourage sustainable growth. Banks must take sustainability into account while developing new products and strive to minimize any unfavorable effects on society and the environment. For instance, lending/investing money to companies who pollute could cause environmental harm and expose the implicated institutions to financial risks. According to Thompson, these financial dangers can be classified into three types: (a) direct risk (legal liability for pollution produced by borrowers), (b) indirect risk (borrowers may have difficulty in repaying loans due to their increased financial responsibilities for the environmental damage caused), and (c) reputation risks (negative public relations
from doing business with environmentally unfriendly firms). Many banks currently use techniques to handle sustainability-related difficulties, such as requiring environmental

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criteria for their loans and implementing environmental management systems, in order to prevent these situations, marketing tactics and initiatives for green financial products. The corporate sector must also play a significant role if the SDGs are to be realized. Even though it is crucial in this regard, the financial sector is falling behind in implementing sustainability principles. Thus, the Bank of England has stated “many banks have some way to go to identify and measure the financial risks from climate change comprehensively”. The SDGs might present an invaluable opportunity for the industry to reinforce its sustainability principles. The United Nations Global Compact and KPMG International have identified four categories in which the financial industry should address the SDGs: (i) financial inclusion; (ii) financing renewable energy and sustainable infrastructure; (iii) sustainability risk analyses in financial decision making; and (iv) influencing corporate clients to address environmental, social and governance criteria in their businesses.

Environmental credit risk management, i.e., the incorporation of environmental risk evaluation into the credit assessment process, is an area of growing importance for banks and other financial institutions. Crucially, financial institutions must create an appropriate framework with which to assess and manage the risks involved in Environmental, Social and (corporate) Governance (ESG) issues, due to the potential material impact of these factors on the bank’s risk profile. From a financial perspective, evaluating the effect of ESG risks on the bank's operations aids in developing a sustainable strategy, allowing for the allocation of sufficient resources to minimize the effects of any potential hazards. Furthermore, when establishing capital, climate-related risks must be considered. In order to increase banks' resistance to these and other risks and consequently make sure the economy is stable. Such a strategy is part of the bank's main goal of determining their essential financial needs.

Concluding Remarks:

Banks have a significant role in aiding the broader economy's adaptability to environmental changes in addition to managing their own risks. By redistributing credit to the economy's most sustainable sectors and controlling credit. Banks lessen the chance of a negative effect on the environment, market risks, and sustainability, lessen the effects of any potential harm, and support the afterward recovery. Banks may use "green banking model” to reduce these

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risks using strategies like the Equator Principles or by joining sustainable banking partnerships. Norms like the Equator Principles facilitate banks' integration of environmental and social credit and operational concerns of major infrastructure into their assessment's investment initiatives.

The consideration of sustainability related factors in Bangladesh affects the institution's risk-adjusted capital ratio (comparing total adjusted capital to the risk-weighted assets held) and its CAMELS rating (a composite value reflecting six areas: capital adequacy, asset quality, management skills, earnings and profitability, liquidity risk, and sensitivity to market risk).

For national level coordination in Bangladesh's perspective, international collaboration, and international coordination, it is imperative to provide a safe and sustainable financial future for everyone. The central bank (i.e., Bnagladesh Bank) of the country has made a paradigm change in response to this fact by adopting sustainable finance policy for banks & NBFIs. The COVID-19 scenario had a significant impact on the country during the quarter under evaluation after the policy was implemented.

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SDConference Proceedings 2022 ISBN: 978-86-87043-85-5

Stakeholders' Disaster Risk Perception and Engagement in a Coastal Area of Thailand

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ABSTRACT

This study has investigated the preparation and implementation of disaster prevention and climate change adaptation measures in coastal areas, identified the relevant stakeholders and their disaster risk perception. Basic information was collected to prepare a questionnaire for future surveys. Preliminary research in May and June 2022 included surveys of central and local authorities, including the Department of Marine and Coastal Resources (DMCR), the municipalities of Songkhla and Muang Ngan in Songkhla province, and the municipality of Chaeng Talay in Phuket province. The interviewees were asked to describe current projects related to disaster prevention and adaptation measures and how administrative plans were designed and implemented, as well as how other stakeholders were involved. Beach erosion control is one of the main DMCR projects, and the criteria for determining the content of projects emphasize environmental friendliness. Such projects include bamboo or timber pile seawalls, mangrove reforestation, and so on. No mention was made of projects related to climate change adaptation by central and local governments were reported. Regarding to stakeholder engagement for any project, public participation is solicited, and design ideas are shared before any project is launched. In terms of disaster risk perception, there is a local resident did not perceive most disasters as crises, while another resident was unique in that he perceived torrential rain and typhoons as crises. In terms of community involvement, both respondents showed a high level of trust in local people and active participation in local activities. Future research will clarify what factors may have caused this difference in disaster risk perception.

KEYWORDS: disaster risk perception, stakeholder engagement, disaster prevention, resilience, climate change adaptation

 ISBN: 978-86-87043-85-5

1 INTRODUCTION

To improve resilience to climate change, defined as the ability to overcome and recover from the extreme events that are expected due to accelerated climate change, collaboration among stakeholders at the local level must respond to the actual community context. Lack of communication between decision makers is a particular problem in coastal areas whose populations have diverse values, although each stakeholder has different roles, responsibilities, and perceptions of disaster risk.
In Thailand, the Department of Environmental Policy and Planning, Ministry of Natural Resources and Environment has taken a leadership role in preparing the National Adaptation Plan on Climate Change. While the plan is being formulated at the national level, but there is a gap with the level of implementation on the ground has lagged behind [1], and a method is needed to prioritize and promote implementation of actions to achieve a resilient society, based on an understanding of the current situation and needs on the ground. Likewise, a method is needed to prioritize and promote the implementation of actions to realize a resilient society, based on an understanding of the current situation and needs in the field [2]. The issues elucidated in this study may contribute to promoting more effective policy planning and implementation in regional governance in coastal spaces. This study has investigated the preparation and implementation of disaster prevention and climate change adaptation measures in coastal areas and identified the relevant stakeholders. Basic information was collected to prepare a questionnaire for future surveys.

2 METHODOLOGY

Disaster-vulnerable areas along the coast of Thailand in Songkhla and Phuket provinces were selected, in accordance with previous studies. Preliminary research in May and June 2022 included a semi-structured interview survey administered to central and local authorities, including the Department of Marine and Coastal Resources (DMCR), the municipalities of Songkhla and Muang Ngan in Songkhla province, and the municipality of Chaeng Talay in Phuket province. The interviewees were asked to describe current projects related to disaster prevention and adaptation measures and how administrative plans were designed and implemented, as well as how other stakeholders were involved (Table 1). Subsequently, a preliminary questionnaire survey was administered to stakeholders interested in coastal conservation and use in a workshop on coastal zoning held in Songkhla province. The survey items included coastal use and value consciousness of the local coast in coastal communities, disaster experience and risk perception, community involvement, and attributes as shown in Table 2.

Table 1 Research Outline for Semi-structured Interview

Topic	Question
Current projects related to disaster prevention and adaptation measures	- Disaster reduction efforts - Perceived risks of natural disasters - Perception of climate change adaptation impacts
How administrative plans were designed and implemented	- Prerequisites, data, etc. - Environment, ecology, economy, landscape, residents' opinions, cooperation - The formulation process
Other stakeholders that are involved	- When and how will stakeholders be involved? And which stakeholders will be involved? - How important is the explanation and cooperation with local

	communities, and how much are their opinions reflected and emphasized? - How do you cooperate with other government agencies?

Table 2 Research Outline for Questionnaire

Topic	Question
Beach	Frequency of going to local beach, value consciousness in coastal communities [3], and priorities for achieving your ideal coast [4]
Disaster	Disaster experience and risk perception [5]
Social characteristic	General trust (trust in people in village) [6] and community involvement
Personal attribute	Age, gender, family member, occupation, income, and educational level

3 RESULTS AND DISCUSSION

Beach erosion control is one of the main DMCR projects, and the criteria for determining the content of projects emphasize environmentally friendliness. Such projects include bamboo or timber pile seawalls, mangrove reforestation, and so on. As each project proceeds, the approval committee at the provincial level includes seven elected experts and the head of the provincial office. Public participation is required before the project is implemented. The priority assigned to the projects depended on the degree of erosion as assessed every five years. No mention was made of projects related to disaster prevention or climate change adaptation.

No projects related to climate change adaptation by local governments were reported. The municipalities of Songkhla and Muang Ngan have budgets for emergencies, and they have sand fences to prevent the large waves caused by monsoons. In the municipality of Chaeng Talay, the budget includes a lifeguard salary, and the Ministry of Digital Economy and Society pays for maintenance to the tsunami warning system tower. As agreed to at a public hearing, the Marine Department provides beach nourishment for coastal erosion control in consultation with the municipality of Songkhla; however, these responses to the public hearing are conducted by the municipality.

In the municipality of Songkhla, public hearings are held regarding project design, so each relevant project can incorporate stakeholders in the project design with a view to collecting opinions from the 55 communities in this area. In the municipality of Muang Ngan, opinions are collected from the local people, and the only stakeholders are the residents. The municipality of Chaeng Talay has a relatively large budget for these purposes, as it is a popular tourist destination. It cooperates with the provincial office of Phuket, the Department of Public Works and Town Planning, and the Ministry of Environmental and Marine Department on tourism, wastewater treatment, and river mouth construction projects. Public participation is solicited, and design ideas are shared before any such project is launched.

A preliminary survey was conducted with two workshop participants, both fishermen and from the target village, with different levels of education: A was in his 50s and had a university degree, and B was in his 60s and had an elementary school degree. Both participants had visited the beach about four times or more per week. Both of them valued the beach as a “healing place,” “new or old playground,” and “place to catch fish.” However, A only experienced storms and typhoons, and B also experienced high tides. In terms of disaster risk perception, A did not perceive most disasters as crises, while B was unique in that he perceived torrential rain and typhoons as crises. In terms of community involvement, both respondents showed a high level of trust in local people and active participation in local activities. Future research will clarify what factors may have caused this difference in disaster risk perception.

4 CONCLUSION

This study has investigated the preparation and implementation of disaster prevention and climate change adaptation measures in coastal areas, identified the relevant stakeholders and their disaster risk perception. Basic information was collected to prepare a questionnaire for future surveys. No mention was made of projects related to climate change adaptation by central and local governments were reported. Regarding to stakeholder engagement for any project, public participation is solicited, and design ideas are shared before any project is launched. In terms of disaster risk perception, there is a local resident did not perceive most disasters as crises, while another resident was unique in that he perceived torrential rain and typhoons as crises. In terms of community involvement, both respondents showed a high level of trust in local people and active participation in local activities. Future research will clarify what factors may have caused this difference in disaster risk perception.

ACKNOWLEDGEMENTS: We would like to acknowledge the help of local residents who cooperated with the interview and questionnaire surveys in Thailand.

FUNDING: This research was supported by JSPS KAKENHI Grant-in-Aid for Early-Career Scientists Grant Number 20K20035.

CONFLICT OF INTEREST: Authors declare no conflict of interest.

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SDConference Proceedings 2022 ISBN: 978-86-87043-85-5

Sustainability Assessment of a Neighbourhood: An Approach to Sustainable Urban Development - Case of Kochi

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ABSTRACT

Rapid urbanization is responsible for the alteration of a range of environmental, social, and economic factors. Urban growth has exacerbated environmental problems, which are linked to unsustainable practices with respect to site management, transportation, waste management, water management, housing, and land use management. Global warming is a major issue that the world is encountering without preparation. Urban heat islands caused by rapid urbanization intensify global warming which in turn results in climate change. Cities are becoming warmer and warmer and undesirable. Sustainable planning in urban areas promotes the management of natural resources to improve the quality of life. Cities and towns are formed by clustering of small units called neighborhoods. Thus, it is considered the building block of cities where most developments occur. Therefore, the sustainability of a city depends on the sustainability of neighborhoods. Achieving sustainability in existing urban areas is essential. To improve sustainability in existing urban areas, a sustainability assessment should be done. However, past studies on sustainability assessment have focused on either the city level or building level, whereas the assessment of neighborhood sustainability, an intermediate level, has received very little attention. This study focuses on the sustainability assessment of existing neighborhoods using the Neighborhood Sustainability Assessment (NSA) tool. This paper focuses on - some design strategies and proposals by assessing the existing sustainability profile of the study area which focuses on the improvement of sustainability and quality of life of residents in the study area, located at Kochi.

KEYWORDS: Neighborhood Sustainability Assessment (NSA) tool, LEED for Neighborhood Development, Sustainable Neighborhood

1 INTRODUCTION

The rapid transformation of rural or semi-rural areas into towns and cities causes changes in the place's characteristics, resulting in population growth and an increase in other infrastructures. This process is referred to as urbanization. It is not only about increasing the number of urban residents or expanding the area of cities, but also about a complete change from rural to urban style in all aspects. Rapid urban growth results in unsustainable practices such as inefficient housing, water management, waste management, and land-use management. It will also reduce vegetation cover, which will lower the rate of carbon sequestration [1].

Several studies show that rapid urban growth results in various environmental problems ranging from local to the global scale, including global warming. As per the studies, urban residents experience more heat stress than rural residents [2]. Urban areas always tend to increase the surface temperature, due to the low albedo materials and reduced green spaces, and this results in the generation of heat islands. These heat islands alter the microclimate and increase the energy demand. Urbanization not only alters the microclimate but also causes the deterioration of the environment.

Global warming is a major issue that is faced all over the world. The generation of urban heat islands by urbanization intensifies global warming which makes cities warmer and results in climate change. Climate change causes extreme weather conditions and climate-related events such as floods, droughts, etc. To reduce the effects of urbanization, sustainable urban planning should be carried out. It will also help to improve the quality of life of residents. The performance of a city is greatly influenced by its neighbourhoods. Effective sustainable planning at the city level can be achieved by improving the sustainability of existing neighbourhoods.

Neighbourhood sustainability assessment (NSA) tools are defined as a set of criteria and themes; and are used to: (a) Evaluate and rate the performance of a given neighbourhood; (b) Assess the neighbourhoods' position on the way towards sustainability, and (c) Specify the extent of neighbourhoods' success in approaching sustainability goals [3,4]. NSA tools help to identify the existing sustainability performance of a neighbourhood and give an insight into the parameters that need to be improved to enhance the performance of the neighbourhood. Several NSA tools are currently in use on a global scale. The following are only a few of the well-known ones: HQE2R, CASBEE-UD, GSAS, IGBC Green Townships, LEED-ND, BCA Green Mark for Districts, BREEAM- Communities, Peral Community Rating System, GBI Township, DGNB for Districts, etc. From this, LEED for Neighbourhod Development (LEED-ND) tool is used to carry out this study, which is a pioneering method in building and neighbourhood sustainability assessment [3].

The main objective of this study is to assess the sustainability performance of an existing neighbourhood by using NSA tools and to study the major issues and quality of life of the residents in the study area. Based on this, the study identifies the major issues and deficiencies of the existing neighbourhood, and sustainable strategies are integrated to improve the sustainability performance of the existing neighbourhood.

 ISBN: 978-86-87043-85-5

2 LITERATURE REVIEW

Since earlier periods human settlements have been split into districts and neighbourhoods geographically, demonstrating the significance of neighbourhoods to the structure of a city. Neighbourhood plays a significant role in the formation of the overall city.
A sustainable neighborhood provides a socially, environmentally, economically healthy, safe, and resilient place to live, work, and play. It acts as a social interactive place that provides all amenities within the neighborhood. It consists of a socially cohesive and diverse mix of housing typologies and amenities for walking, cycling, and proper transit facilities. These neighborhoods promote energy efficiency and conserve the environment from major impacts of urban development by efficient use of resources. It provides residential areas and recreational facilities in closer proximity which enables the residents to use alternative transportation facilities such as cycling.

2.1 Criteria and indicators of the sustainable neighborhood

Social aspect:

- Education Facilities
- Health facilities
- Identity and vitality of neighbourhood
- Individual and social security
- Recreation and leisure
- People participation / Public relation
- Food security

Environmental aspect:

- Green and open space Pollution
- Natural landscape
- Population density
- Building density

Economic aspect:

- Employment
- Diverse housing
- Transport and communication facilities
- Facilities and infrastructure services

2.2 Neighborhood Sustainability Assessment tools

Sustainability assessment is the assessment done to assess the sustainability performance of neighbourhood. There are several tools that enable to do the assessment of neighbourhood called neighbourhood sustainability assessment (NSA) tools. These tools have great potential for the transition of neighbourhoods towards sustainable development. It provides context-based sensitive results by reviewing the existing condition of the neighbourhood. There are several NSA tools available such as LEED-ND, BREEAM communities, CASBEE city, DGNB urban districts, IGBC green townships, etc [6].

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List of NSA tools:

Table 1 List of Neighbourhood sustainability assessment tools [6]

Tool	Main developer	Origin	Year
HQE2R	Scientific and Technical Centre for Building (CSTB)	France	2001
CASBEE-UD	The Institute for Building Environment and Energy Conservation (IBEC)	Japan	2007
Global Sustainability Assessment System (GSAS)	Gulf Organisation for Research and Development	Qatar	2007
IGBC Green Townships	Indian Green Building Council	India	2008
LEED-ND	US Green Building Council (USGBC)	US	2009
BCA Green Mark for districts	Building and Construction Authority (BCA)	Singapore	2009
BREEAM-Communities	Building Research Establishment (BRE Global)	UK	2009
Pearl Community Rating System	Abu Dhabi Urban Planning Council	UAE	2010
GBI Township	Green Building Index Sdn Bhd (GSB)	Malaysia	2011
DGNB for Districts	German Sustainable Building Council	Germany	2012
Green Star Communities	Green Building Council Australia (GBCA)	Australia	2012

2.3 NSA TOOL - LEED for Neighbourhood Development (LEED-ND)

Leadership in Energy and Environmental Design for Neighbourhood Development is a rating system that is dedicated to neighbourhood scale assessment. This is a major tool that is used to assess the performance of a neighbourhood. LEED-ND comprises a set of categories such as smart location and linkage, neighborhood pattern and design, green infrastructure and buildings, innovation, and regional priority credits. This is a credit-based rating system. Depending upon the credit-scored, the project can be rated as silver, gold, and platinum.
The main intent of this rating system is to promote healthy, durable, affordable, and environmentally friendly practices in design and construction. This rating system can be used to evaluate the performance level of the neighbourhood and finding out remedies to enhance the performance level. This enables us to achieve a compact, mixed-use neighbourhood with all amenities that can be accessed easily [5].
LEED ND 2009 has five main categories: Smart location and linkage (SLL), Neighbourhood pattern and design (NPD), Green infrastructure and buildings (GIB) , Innovation and design process (IDP), and Regional Priority credits (RP).

2.3.1 Smart Location and Linkage (SLL)

This category mainly focuses on site selection and where to build or how to choose a site for neighbourhood development. It encourages development near the existing transit facilities by conserving and protecting the ecological communities and species. It also promotes wetland and water body conservation along with agricultural land conservation to avoid the formation of flood plains. Reuse of land by brownfield redevelopment is also considered thus helping to reduce pressure on undeveloped land. Larger credit in this category includes the promotion of alternative transportation facilities to reduce automobile dependence, thereby reducing pollution and greenhouse gas emissions [5].

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2.3.2 Neighborhood Pattern and Design (NPD)

This category focuses on internal connectivity and compact development to protect the existing undeveloped land. This gives insight into what to build. It encourages walkable streets, diverse communities, improvement of transit facilities, etc. The main intent is to reduce the usage of private vehicles and to increase the usage of public transit facilities thus reducing the parking footprint and traffic congestion. This also focuses on the improvement of access to civic facilities and recreational facilities. Facilities such as schools and local food production facilities are also included in this category [5].

2.3.3 Green Infrastructure and Buildings (GIB)

This category focuses on the mitigation of environmental impacts and strategies that can be adopted to improve building performance in terms of building energy efficiency, building water efficiency, water-efficient landscaping, retrofitting of old buildings, and reuse of existing abandoned buildings. This category also gives more importance to waste management, light pollution reduction, mitigation of urban heat islands, on-site renewable energy production, etc [5].

2.3.4 Innovation and design process (IDP)

This category encourages innovative design ideas that will enhance the smart growth of the neighbourhood. It also provides credit to the inclusion of LEED-accredited professionals [5].

2.3.5 2.4.5 Regional priority credits (RP)

This credit aims to incorporate regional variations into the evaluation system [5].

3 STUDY AREA

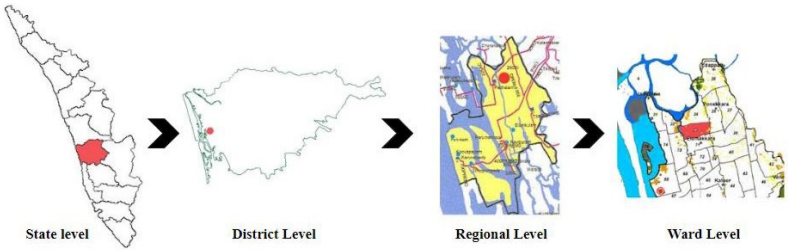

Figure 1: Location Map

The proposed site is Elamakkara, situated in the western portion of Kochi in the Ernakulam district of Kerala. The total site area is about 0.98 Km Sq (242.2 Acres). It is one of the prime residential localities of Kochi, Kerala. The settlement pattern of the neighbourhood is a compact low-rise settlement with 80% residential and 20% of commercial buildings. The eastern and western side of the neighbourhood is bordered by waterbodies.

3.1 Population density

The population of this neighborhood is 8939 in 2001, 10274 in 2021, and the projected population for 2041 is 10490. Population density is 63 person/hectare as of the 2001 survey

[Kerala census data 2001]. The projected population density for 2021 is 67.45 people/hectare. Building density ranges from 6.5 - 11 Du/Acre. [7]

3.2 Topography

The site is bordered by water canals in the East and the West. Therefore, the elevation of the site ranges from 11 meters to 2 meters above mean sea level (MSL). Land near the water bodies is low-lying areas with an elevation of 2 meters to 4 meters above MSL. And this area is mostly waterlogged and prone to flooding.

3.2.1 Elevation profile

According to the study done by Sowmya K and C M John on the elevation profile of cochin city, the major portion of the proposed site comes under 6-10 meters above mean sea level. Some of the regions are above 10 - 19 meters and a small portion comes under 0-3 meters above mean sea level. Thus, the portion under 0-3 meters above mean sea level is not habitable [7].

3.2.2 Coastal Regulation Zone [CRZ]

A small portion of the site near to the canal falls under CRZ II, it constitutes the developed areas up to the shoreline, which fall within the existing municipal limits.

3.3 Water bodies

Kochi is one of the major seaports in India and the safest harbor in the Indian Ocean. Kochi is rich in its Inland water networks and waterway system which consists of lagoons, backwaters, canals, and estuaries. Major water transportation network, such as the National waterway connecting Kollam and Kottappuram also passes through this region. Major water bodies passing through Kochi are canals, and later join the river and flow into the sea. The main canals in Kochi city are Edappally Canal, Thevara - Perandoor Canal, and Chilavanoor Canal [8].

3.3.1 Micro-level water bodies

The canals passing through the site are Thevara - Perandoor canal and the Chilavanoor canal. Thevara - Perandoor canal is located on the western side of the site and the Chilavanoor canal in the eastern side of the site. These two canals make the ward boundary.

3.4 Physiography

The district consists of well-defined units, High-lands, Mid-lands, and Low-lands. Highlands are mostly located in the eastern and northern portions of the district, where the midlands occupy the center portion and the lowlands in the eastern part of the district. The lowlands in the district lie between the backwater and the sea. As per the natural resources data bank of Ernakulam, the study area lies on low land.

3.5 Geology

As per the Natural Resources Data bank study report, a major part of the district consists of Charnockite and migmatite groups of rocks of Precambrian age. The study area mainly

 ISBN: 978-86-87043-85-5

consists of sand and silt which are Palaeo beach ridge deposits (sand) and flood plain deposits (silt, sand, clay).

3.6 Geomorphology

As per the Natural Resources Data bank study report, the study area lies in the coastal plain. The coastal plain is a low-lying area, with a maximum elevation of around 10 meters, which is characterised by backwater bodies, marshy lands, sandy flats, and alluvial plains.

3.7 Soils

The soil typology in the study area is found to be a K0, which is deep moderately well-drained soil. It consists of sandy soils, with a moderately shallow water table on gentle slopes [Natural resources data bank – Ernakulam].

3.8 Land use change

As per the study conducted by Sajith K.S [9], the land use map of the site during 1967 was having mixed land use. And the banks of the canals are in seasonally flooded areas. In 2019, the land use of the site changed from Mixed land use to a Highly habited area.
From this change in land use, will be able to understand the changes that had happened over the years. This land use change has exerted pressure on the environment which results in climate change.

3.9 Climate of Kochi

Kochi has a tropical climate with abundant rainfall and sunlight. As per the Kappen climate classification, Kochi comes under Tropical Monsoon Climate (Am). The annual temperature of Kochi ranges between 22° C and 32° C and an annual rainfall of around 3000mm since it lies on the windward side of the Western Ghats. Since it is a coastal region and the presence of a large area of backwaters, humidity in this region is high throughout the year.

3.9.1 Temperature

March-May is the hottest month in Kochi. Maximum temperatures occur during March and April with more than 95°F (35°C).

3.9.2 Cloud cover

Most sunny days are experienced during the months of January and February. The regions in Kochi experience partly cloudy during April, May, September, and October. Sky overcast is during the months of June, July and August.

3.9.3 Wind

The wind is blowing from the Southwest to the Northeast direction. This also contributes to gaining more rain in this region. More windy days are experienced during April, May, and June. Less windy days are during November, December, and January.

3.9.4 Precipitation

Kochi receives abundant rainfall. The Wettest months are experienced during June, July, and August. Dry days are experienced during the period from December to March.

3.9.5 Humidity

Kochi experiences high humidity throughout the year due to the presence of sea and backwaters. High humidity is experienced from April to June. Less humidity is during December and January. But most of the days are muggy that lasts for 11 months and 92% of the time it is oppressive and miserable.

3.10 Site survey

A site study was conducted to study the settlement pattern, existing land use, livelihood of residents, and quality of life of residents in the study area. To analyze these parameters, a survey was conducted among the residents in the study area. From the survey, I was able to find the current issues that are faced by the residents in the neighbourhood and the existing facilities that are available in the neighborhood. This helped me to sort out the needs of the residents and arrive at strategies for the neighbourhood by referring to the LEED-ND guidelines.

4 MATERIALS AND METHODS

After understanding the different neighborhood assessment tools, LEED for Neighborhood development is chosen for the assessment of neighbourhood. Prior to the assessments, a study is done along with the site survey. The site survey was conducted among the residents of the neighbourhood. This helped to identify the typology of residents, existing conditions, and amenities that are available in the neighbourhood.
The neighbourhood sustainability assessment is carried out in two stages using the LEED-ND checklist. At the primary stage, the existing neighborhood is assessed, and the credit points acquired are noted. Several design solutions and strategies are suggested to improve the sustainability performance of the neighborhood.
A secondary assessment is carried out by considering the proposed design strategies to the existing neighbourhood and the total credit points acquired are noted and compared with the initial credit points. Thus, the sustainability performance of the neighborhood is assessed.
To prove the compatibility of the suggested design proposals, outdoor simulations are carried out using ENVI -met software, and results are analyzed.

5 RESULTS AND DISCUSSION

This section presents neighbourhood assessments, results, and observations.

5.1 Neighborhood Sustainability Assessment – Existing case

5.1.1 Smart Location and Linkage (SLL)

Sustainability assessment of neighbourhood is done using the LEED for Neighbourhood Development checklist and scoring is done. The first category of this rating system is smart location and linkage, which discusses location, ecosystems and open spaces, contaminated sites, transit-oriented locations, cycling facilities, and job and housing proximity.

The neighbourhood is located on an infill site. As per LEED-ND, the infill is 75% of the site surrounded by existing development. According to the assessment by site study, the neighbourhood comes under the infill site category since it is surrounded by more than 75% of existing development. The neighbourhood is well connected by street networks and transit amenities. As it is an infill site and a previously developed site, 5 credit points are scored under LEED-ND SLL credit 1 preferred locations.
The neighbourhood has a good and well-connected street network. As per the assessment, the intersections of the neighbourhood are between 135 to 154 intersections per square kilometer, 4 points are scored under SLL credit 1 preferred locations.
Due to urbanization, some of the species are found to be threatened and endangered as per the biodiversity study report [Local Biodiversity Strategy and Action Plan for Kochi Municipal Corporation]. The low-lying land near the Perandoor canal and Chilavanoor canal is developed and there is no buffer of undeveloped land around them. Thus, the SLL prerequisites 2 and 3 cannot be achieved. As per the site study, the neighbourhood was not farmland and thus agricultural land conservation credit is achieved.
Since the site does not conserves pre-existing on-site habitat, and native plants, restores degraded on-site habitats, wetlands, and water bodies, and does not have long-term plans SLL credit 7,8,9 is not scored during the assessment. The neighbourhood was not a contaminated brownfield site, the brownfield redevelopment credit is not applicable to this neighbourhood.
When assessing the transit-oriented location of the neighbourhood, the neighbourhood has a well-connected road network. But the access to water transportation is less even though the neighbourhood has the well potential to connect to a water transportation network. Under the SLL credit-3 locations with reduced auto dependence, 3 points are scored as per the number of transit services. There is no existing cycling facility in the neighbourhood. The neighbourhood provides jobs on an infill site which has an 800 meters distance between the existing transit stop and housing. Thus, SLL credit-5 is achieved.
By assessing the Smart Location and Linkage category, 13 points are scored from 27 possible points.

5.1.2 Neighborhood Pattern and Design (NPD)

This category of the LEED-ND discusses walkable streets, compact development, neighbourhood connections, affordable and diverse housing, parking, and transportation demands, parks and recreation, universal design, community participation, local food, school access, and design.
All buildings in the neigbourhood have entries to a public space such as streets or roads. The building-height-to-street width ratio of 1 to 3 is only present on the main roads and streets and lanes are narrow. Sidewalks are present along both sides of the main roads. Most of the building follows a minimal distance between sidewalks. On-street parking is available on main roads. NPD credit 1 walkable street is achieved with a score of 6 out of 12. Available streets are not comfortable for walking during the daytime due to lack of shade. Thus, the shading of walkways helps to improve the usage of sidewalks.
The assessment of NPD prerequisite 2 compact development shows that the density of dwelling units ranges from 7 – 11 dwelling units per acre. Thus, this enables us to score a point in NPD credit 2 compact development as per the criteria. The neighbourhood has access to streets or pathways and intersections which helps to connect all regions of the neighbourhood and access to all commercial or civic uses. The available intersections do not include cul-de-sacs and the neighbourhood has intersections between 116 to 154 per square kilometer.

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After analyzing the affordable and diverse housing, Simpson's diversity index is .51, which is greater than and less than .6. Thus, one point is achieved as per the NPD criteria.
Parking and transportation demand analysis of the neighbourhood shows that there is no enough parking space in the neighbourhood both for vehicles and bicycles. Thus, there is a need for a proper parking facility that allows people to use it at their convenience.
Credit 10 access to recreation facilities in the NPD category analyses the availability of recreation space in the neighbourhood. As per the analysis, there is a common playground in the neighbourhood. Most of the residents have access to this space within 800 meters. But there is no green open space in the neighbourhood such as squares, or parks.
There are three schools in the neighbourhood that can be accessed within 800 meters. People in the neighbourhood do not have space to produce local food. From the survey, the interest of residents in local food production is analyzed. Thus, providing space for local food production will help to improve the production of local food products.
Thus, all together in the NPD category, points scored were 12 out of 44.

5.1.3 Green Infrastructure and buildings (GIB)

Green Infrastructure and Buildings category discusses green construction techniques, energy efficiency and conservation, energy production and distribution, water efficiency and distribution, stormwater and wastewater, green buildings process, Historic, and existing building reuse, Heat islands, reuse and recycling, and light pollution.
The sustainability assessment is done in this category, but the existing neighbourhood does not have green infrastructure and other energy conservation practices. Therefore, no points are gained from this category. But from the site study, the possibility and potential of adopting green building techniques have been identified.
Currently, there are no sustainable practices followed in the neighbourhood. Local energy production and other practices such as heat island reduction, and light pollution reduction are also not practiced. Proposing practices that can be adopted in the neighbourhood to improve sustainable practices will help to reduce energy consumption and thus reduce energy demand.

5.1.4 Innovation and Design Process (IDP) and Regional Priority Credit (RP)

The IDP credit assesses the innovation and exemplary performance in the neighbourhood and the RP credit assesses the geographical-specific, environmental, and social equity-specific priorities that exist in the neighbourhood.
From the assessment, no credit point was achieved in these two categories. There are no innovative performance and RP priorities that are addressed in the neighbourhood.

Table 2 Neighbourhood sustainability assessment - Existing case

LEED – ND Categories	Points Achieved	Possible Points
Smart Location and Linkage	13	27
Neighbourhood Pattern and Design	12	44
Green Infrastructure and Buildings	0	29
Innovation and Design Process	0	6
Regional Priority Credits	0	4
Total points	**25**	**110**

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5.2 Neighborhood Sustainability Assessment – Proposed case

5.2.1 Smart Location and Linkage (SLL)

A secondary assessment is performed after proposing design solutions and strategies to the existing neighbourhood to improve the sustainability performance of the neighbourhood. In the SLL category, credit 7-site design for habitat/wetland conservation, and credit 8-Restoration of habitat/wetlands are considered. Therefore, existing trees and 20% of undeveloped are conserved and vegetation is restored in the vacant lands to improve the green cover and reduce the urban heat island effect.

The existing neighbourhood is not directly connected with the existing water metro network of Kochi. Thus, proposing a boat jetty at the western portion of the neighbourhood located on the banks of the Perandoor canal enables to connect the neighbourhood with the existing nearest water metro terminal located at Vaduthala, South Chittoor, and Mulavukad north terminals which is 3.5 Km away. By this proposal, SLL credit-3 Locations with reduced auto dependence are improvised and one more point is scored in this credit. A transit stop is also proposed near to the existing school to improve the accessibility to public transportation and thus improve the transit facilities.

And altogether in the SLL category, four more points are scored by implementing design proposals to the existing neighbourhood, and the total points scored in this category becomes 17.

5.2.2 Neighborhood Pattern and Design (NPD)

Neighbourhood pattern and design category is assessed. To improve the walkability of the neighbourhood, pedestrian paths are proposed. Lanes and streets are lined with non–invasive trees. This will help to improve the noon-time shading. The low design speed of 20mph for residential areas and 25mph for non-residential areas are proposed as per the LEED-ND guidelines. Which will help to increase the convenience of using bicycles.

Lack of parking space in the neighbourhood is a major issue that is faced by the residents in the neighbourhood. To solve this, a proper parking facility is proposed which reduces the on-street parking and congestion in the lanes and streets. This improves circulation through the streets and lanes. By this, NPD credit-5 is achieved. The transit facility is also improved by providing information displays at existing and new transit stops. This helps to achieve NPD credit-7 transit facilities.

A good neighborhood consists of green open spaces and recreation spaces that can be accessed by all residents in the neighbourhood. In this neighbourhood, outdoor recreational facility (Elamakkara playground) is available. But the neighbourhood lacks open green spaces such as squares or plazas. Thus, an open green recreation space is proposed which can be accessed by all residents within 800 meters by cycling or walking. Thus achieves the NPD credit-9 access to civic/public spaces.

All the proposed open spaces in the neighbourhood are universally accessible. Local food production is improved by providing a dedicated space in the neighbourhood for local food production. This is managed by residential associations in each region. This helps to increase job opportunities and social equity.

Altogether, the NPD credit score increased from 12 to 21 which indicated the improvement in the facilities and sustainability profile of the neighbourhood in the NPD category.

5.2.3 Green Infrastructure and buildings (GIB)

Green infrastructure and building credit are assessed after implementing several design proposals and strategies in the existing neighbourhood. Major proposals include the preservation of 10% to 20% of existing undeveloped land and the restoration of vegetation is done in these lands. Onsite energy is produced by means of installing solar panels. Thus, a minimum of 6% of the total energy demand can be produced in the neighbourhood.
The GIB category credit-5 supports the restoration of old buildings in the neighbourhood. One such building is identified which is abandoned and this can be utilized as a public library for the neighbourhood. Apart from this, mitigation of the heat island effect in the neighbourhood is also considered in this category. To mitigate the heat island effect of the neighbourhood, cool roofs/green roofs are proposed for about 60% of the buildings in the neighbourhood. This will help to reduce heat absorption and radiant temperature. Paving in the neighbourhood is also replaced with high albedo permeable pavements that allow infiltration of water and reduce the risk of flooding in the neighbourhood.
Light pollution is reduced by replacing the existing streetlights with motion sensor lights and solar streetlights. All outdoor lights in the neighbourhood are fixed downward which reduces the amount of reflected light to the sky and avoids skyglow. It also reduces energy consumption and improves energy efficiency.

Table 3 Neighbourhood sustainability assessment - Proposed case

LEED – ND Categories	Points Achieved	Possible Points
Smart Location and Linkage	17	27
Neighbourhood Pattern and Design	21	44
Green Infrastructure and Buildings	7	29
Innovation and Design Process	0	6
Regional Priority Credits	0	4
Total points	**45**	**110**

5.2.4 Analysis

Table 4 Comparison of primary and secondary assessment

LEED – ND Categories	Primary assessment	Secondary assessment
Smart Location and Linkage	13	17
Neighbourhood Pattern and Design	12	21
Green Infrastructure and Buildings	0	7
Innovation and Design Process	0	0
Regional Priority Credits	0	0
Total credit points scored	**25**	**45**

The total points scored during the secondary assessment was 45 and the score during the primary assessment was 25. Thus, by implementing the strategies into the existing

neighbourhood, 20 points were achieved. This shows a good improvement in the sustainability profile of the existing neighbourhood. This assessment not only helped to improve the sustainability performance but also helped to improve the basic amenities of the existing neighbourhood.

One of the major proposals includes the replacement of impermeable low albedo paving material with high albedo permeable pavements. To check the compatibility of this proposal, a simulation was performed using ENVI-met lite software to assess the surface temperature difference between the existing case and the proposed case. The surface temperature of the region with asphalt roads is above 42.74 degrees Celsius and concrete pavement with a low albedo value is 35.11 degree Celsius.

After simulating the region by replacing the pavement with permeable pavement having a high albedo value, the surface temperature of the region with reflective pavement decreased from 35.54 degrees Celsius to 27.46 degrees Celsius.

Thus, the result shows a decrease in surface temperature which will help to reduce the heat island effect of neighbourhood if the pavements are replaced with permeable reflective pavements. The permeability of pavements also helps in the draining of water into the soil and reduces the possibility of the formation of floods in the neighbourhood.

6 CONCLUSION

Neighbourhoods act as clusters of a city. Thus, achieving sustainability at this clusters helps the city to perform better. Rather than focusing on the new developments, more focus should be given to the existing developments. Improving the sustainability of existing buildings/ neighbourhoods will help to reduce the negative impacts caused due to rapid urbanization. From this study, an assessment of the neighbourhood done using the LEED-ND checklist indicates a low sustainability performance of the existing neighbourhood. The site study and survey indicate the lack of amenities in the neighbourhood such as recreational facilities, green open spaces, cycling paths, shaded pathways, etc. The environmental performance and quality of life were also low. This indicates the weakness in planning and policy making.

Thus, several design proposals and strategies are suggested to improve the neighbourhood quality and thereby in lieu of thus improving sustainability of the neighbourhood. After this, assessment is repeated to analyze the efficiency and sustainability performance of the neighbourhood. Results show an increase in the sustainability performance of the neighbourhood.

The findings from this research show that integrating NSA tools while planning a neighborhood/community will contribute to more sustainable living and will improve the quality of life in the city.

Therefore, this methodology can be adapted to other neighbourhoods in Kochi and other cities to assess the sustainability performance and to analyze the major issues of the neighbourhood. It will help to make good decisions in policy making and tackle unsustainable practices. Thereby leading to sustainable urban development.

ACKNOWLEDGEMENTS: The authors wish to acknowledge the support of all faculty members of the College of Engineering Trivandrum for their valuable suggestions and comments during the research.

FUNDING: This research received no external funding.

CONFLICT OF INTEREST: Authors declare no conflict of interest.

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SDConference Proceedings 2022 ISBN: 978-86-87043-85-5

Sustainability Window (SuWi) Method For Doughnut Economy Model Construction. Assessment of Development in China, India, USA and Finland

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ABSTRACT

Sustainability assessment methods need to include different dimensions in a coherent analysis and comprehensive view of the development. In the basic form, sustainable development can be seen to include three dimensions: environmental, social and economic. These can be further developed in different sub-dimensions depending on the need for analysis and available information.
Sustainability Window (SuWi) is a novel method developed for the analysis of the sustainability of economic growth. SuWi method provides, on the one hand, information about the maximum economic development not to exceed the environmental limit of sustainability and, on the other hand, information about the minimum economic development to fulfil social sustainability. These minimum and maximum economic development determine the Sustainability Window.
SuWi method results can be used for constructing the Doughnut Economy model where the outer limit of economic development is determined by the environmental constraint and the inner limit by the social development need. This quantitative model illustrates the sustainable operation area for society.
In this paper, we have calculated the SuWi results for China, India, the USA and Finland to illustrate the method and constructed the Doughnut Economy model for these countries based on the SuWi results.

 ISBN: 978-86-87043-85-5

The results indicate that there are different problems of sustainability in the analysed countries and sustainability strategy should be constructed based on the various challenges that the countries have.

KEYWORDS:
sustainability; sustainable development; Sustainability Window (SuWi); Doughnut Economy;

1 INTRODUCTION

The definition of Sustainable Development is often taken from the publication 'Our Common Future' [1] published by the Brundtland Commission. In this definition, it is stated that "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs". This definition emphasizes the needs approach and the possibilities to fulfil social needs without causing harm to the environment which could prevent future generations to live a decent life.

It is not easy to measure sustainable development and several different ideas and concepts for the measurement are proposed. Sustainable Development Goals (SDGs), developed in the UN framework [2], is a comprehensive system to classify different dimensions of sustainability and to measure the performance of different countries. There are also several other indicator systems developed for the assessment of sustainable development [3], [4] [5], [6].

Sustainable development is many dimensional process which is difficult to compress into a few indicators. The dimensions of development are interlinked and impact each other and that is why a comprehensive analytical framework is needed to illustrate the character of development. This article proposes a framework called Sustainability Window (SuWi) to be used for analysing the sustainability of development simultaneously in different dimensions of development to get a holistic view of the development. Next, the results of SuWi analysis are organised in a form to construct a model for Doughnut Economy for easy visual interpretation of the results.

2 METHODOLOGY AND DATA

2.1 Data sources

The data for the analyses is collected from Sustainable Society Index [3] and United Nations Sustainable Development Goals [4]. The analyses utilize time series data and that is the reason why special attention is paid to the continuity of the time series and the similarity of the base data for indicator construction. The data for the analyses covers the years 2006-2016 where reliable data was available in the SSI database. A detailed explanation of the indicators can be found in [3].

2.2 Sustainability Window method

Sustainability Window (SuWi) is a method to determine the maximum economic development not to exceed the environmental limit in the production of environmental stress. The environmental limit can be determined to be relative to some previous year's value (for instance reduction of environmental stress from base years value) or an absolute target based on the ecological evaluation. The determination of the absolute target is often not based on scientific fact, like the carrying capacity of the ecosystem, but on a political decision where

 ISBN: 978-86-87043-85-5

other aspects are also taken into account. The SuWi method can be used in both cases of the relative or absolute target.

Weak sustainability criterion means that the environmental stress intensity (environmental stress/GDP) should not increase, i.e. the development is sustainable if the environmental stress increases slowlier than the economic growth. The strong sustainability criterion means that environmental stress should not increase. In these analyses, we have used strong sustainability criteria.

Figure 1 illustrates the construction of the Sustainability Window. In this example, we use Greenhouse gas emissions as an indicator of the environmental dimension, Healthy Life Years as an indicator of the social dimension and GDP as an indicator of the economic dimensions. Indicators are indexed so that the base year value for each indicator is 1. The economic dimension of the development is expressed on the x-axis and environmental and social dimensions are on the y-axis. Point A shows the starting point in the base year and line r1 illustrates the environmental stress productivity of the economy as well as the social welfare productivity. Point B shows the value of the social indicator four years after the base year and line r2 the social welfare productivity which has decreased in this example. If the social sustainability criterion is that the social welfare should not decrease point C determines the minimum economic development if the welfare productivity remains at the level r2 (ceteris paribus). This GDP_{min} determines the minimum level of economic development.

The greenhouse gas emissions, in this example, are at point C in the fourth year and this determines the environmental stress productivity line r3. If the environmental sustainability criterion is that the environmental stress should not increase the line r3 determines the maximum economic development GDP_{max}, point E, not to exceed the environmental burden. The Sustainability Window is now determined by $GDP_{min} < SuWi < GDP_{max}$.

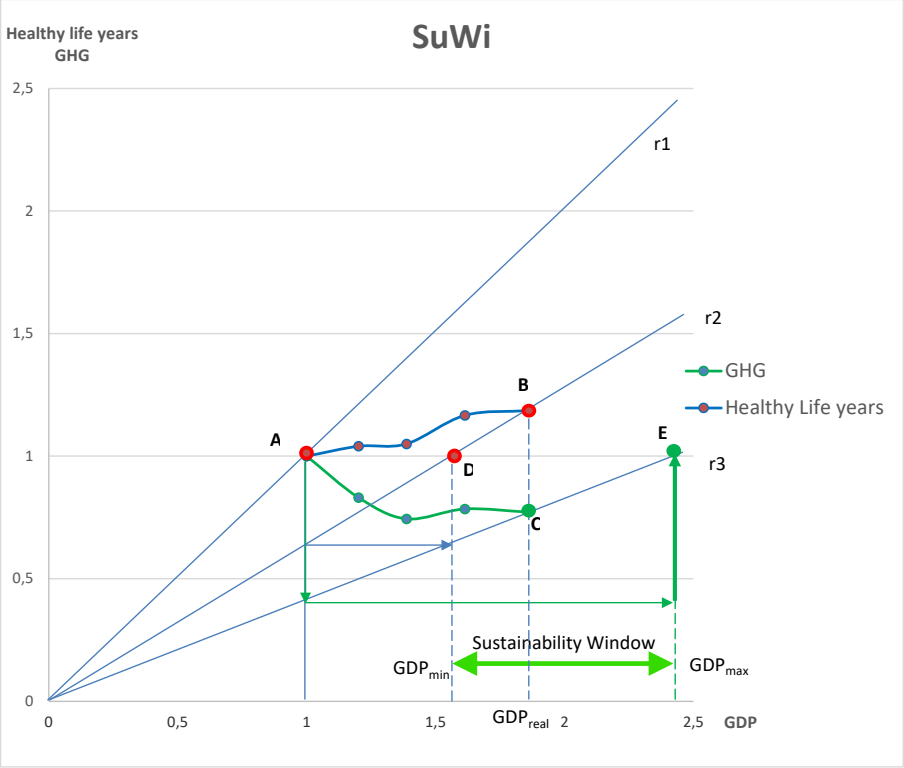

Figure 1. Determining the Sustainability Window with the development of social welfare (Healthy Life Years), environmental stress GHG emissions) and economic (GDP) indicators.

 ISBN: 978-86-87043-85-5

If the real GDP growth is within the SuWi we can determine the development to be sustainable in relation to the used indicators. If $GDP_{min} > GDP_{max}$ the Sustainability Window does not exist. There are several possible combinations of SuWi depending on the values of the indicators (increasing or decreasing) and the changes in environmental stress and social welfare productivities. These are discussed in detail in [7].

This type of sustainability window can be constructed for different pairs of social and environmental indicators and it can be used to analyse also the trend of the changes for sustainability. The dynamic SuWi analysis [8] provides information on the development process and it can be used as a basis for scenario construction.

When the results of SuWi analyses are organized in a radial diagram we can construct the Doughnut Economy model. According to Kate Raworth [9] “The environmental ceiling consists of nine planetary boundaries, as set out by (Rockström et al., 2009), beyond which lie unacceptable environmental degradation and potential tipping points in Earth systems. The twelve dimensions of the social foundation are derived from internationally agreed minimum social standards, as identified by the world’s governments in the Sustainable Development Goals in 2015. Between social and planetary boundaries lies an environmentally safe and socially just space in which humanity can thrive.” The SuWi analysis provides quantitative information on these boundaries and the related economic development. The method provides a visual interpretation of the Doughnut and indicates where the problematic unsustainable development areas exist.

3 RESULTS

3.1 Doughnut Model

When the results of SuWi analyses are organized in a radial diagram we can construct the Doughnut Economy model. According to Doughnut Economy developer Kate Raworth [9] “The environmental ceiling consists of nine planetary boundaries, as set out by Rockström et al., [10], beyond which lie unacceptable environmental degradation and potential tipping points in Earth systems. The twelve dimensions of the social foundation are derived from internationally agreed minimum social standards, as identified by the world’s governments in the Sustainable Development Goals in 2015. Between social and planetary boundaries lies an environmentally safe and socially just space in which humanity can thrive.” The SuWi analysis provides quantitative information on these boundaries and the related economic development. The method provides a visual interpretation of the Doughnut and indicates where the problematic unsustainable development areas exist.

We have carried out analyses of the Doughnut Economy for China, India, the USA and Finland. The countries were selected for the analyses because they are crucial for global development both in the economic and environmental sense. Finland is added to the analysis because it illustrates a small open economy developed country with a good statistical basis. It has to be remembered that the comparison here is now based on relative changes from the base year 2006 value. The starting point for instance in per capita emissions of CO_2 is very different for the analysed countries; India 0.98 ton, China 4.6 ton, Finland 12.6 ton and the USA 18.8 ton per capita. It cannot be expected that India reduces the CO_2 emissions in the same way as the USA. If we assume that the general sustainable target for CO2 emissions in the world is about 1.8 tons per capita we can construct the following figures 2 and 3 to illustrate the required emissions reductions in India and the USA with indexed data.

Figure 2 shows the historical development part of emissions per capita and economic development in India from the year 2006 from point A to point B. If we assume CO2 emission intensity to remain at the same level as in the final year of analysis (ceteris paribus),

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illustrated with r2, the maximum economic development could reach GDP_{max} without exceeding the sustainability target of 1.8 tons per capita (point C).

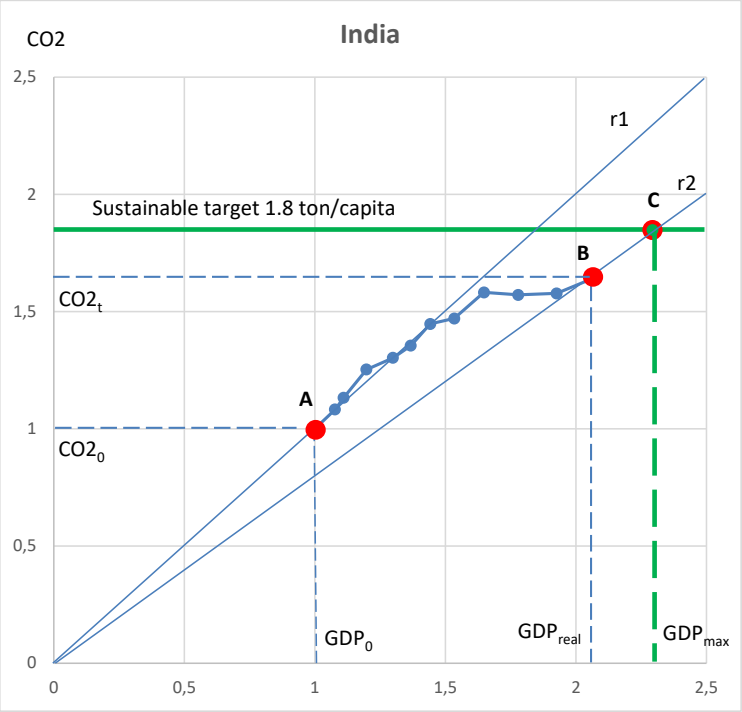

Figure 2. Analysis of the maximum level of economic growth in India if the sustainable target of CO2 emissions is 1.8 tons per capita. Point A refers to base year values of CO_2 emissions per capita and GDP and point B to last year's values. With the emission intensity r2 the maximum economic development is GDP_{max} not to exceed the sustainability target of emissions.

A similar analysis is carried out for the USA in Fig 3. Now the real GDP level in the final year of analysis is much too high to reach the sustainability target. The emissions intensity should be reduced considerably from the value r2 to the level of r3 or the economic growth should be reduced to the level of GDP_{maxr2} in order to reach the sustainable emission level.

Next the Doughnut Model analysis based on SuWi results will be presented. We have used the indicators shown in Table 1 for the analysis of the Doughnut Economy for China, India, the USA and Finland.

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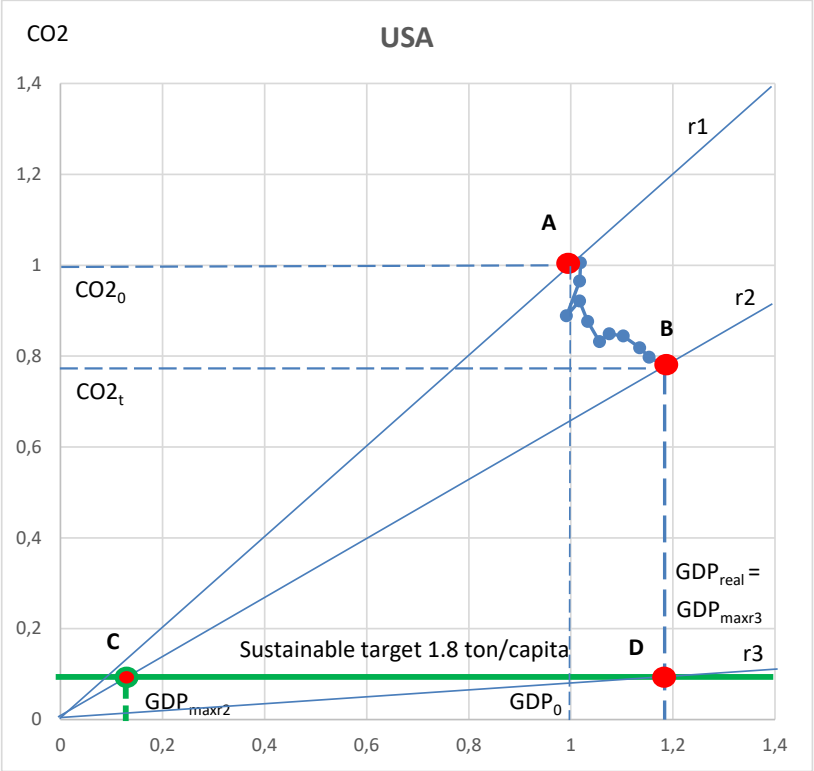

Figure 3. Analysis of the maximum level of economic growth in the USA if the sustainable target of CO2 emissions is 1.8 tons per capita. Point A refers to base year values of CO_2 emissions per capita and GDP and point B to last year's values. With the emission intensity r2 the maximum economic development is GDP_{maxr2} not to exceed the sustainability target of emissions. If the emission intensity can be reduced to the level r3 the maximum sustainable economic growth would be $GDP_{maxr3} = GDP_{real}$.

Table 1. Indicators used in the SuWi analysis and Doughnut Model for ASEAN countries.

Economic		**Environmental**		**Social**
GDP	Forest, For	Biodiversity, Forest area	Food	Sufficient food
	Conservation, Conse	Biodiversity, Protected area	Drink	Sufficient to drink
	Water	Renewable water resources	Edu	Education
	Consu	Consumption of global hectares	HLY	Healthy life years
	Intens	Energy intensity	Gend	Gender equality
	CO2	CO_2 emissions	Inc	Income distribution
	Ren energy	Renewable energy	Emp	Employment
	Organic	Organic farming	Soc inc	Social inclusion
	Sanitation	Safe sanitation	HDI	Human development

Figure 4 illustrates the results of SuWi analyses for China organized in the Doughnut Model form. The minimum and maximum values Sustainability Windows constructed for different pairs of social and environmental indicators are organized in a radial form to visualize the problematic areas of development. The maximum economic development in the case of different indicators, in relation to environmental development, is shown with the blue line. The minimum economic development, to guarantee sustainable social development, is

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indicated with the green line. The area between the blue line and green line, marked with green colour, forms the sustainable space for economic development, the Doughnut. Real economic development is indicated with the red line. The optimal situation would be if the red line would be on the green background because in that case, the development would be sustainable in relation to all the used indicators.

In the case of the Chinese development, the Doughnut Model indicates that the development of sanitation and energy intensity (savings) are well under control and fulfil environmental sustainability. Also, the use of renewable water is within sustainability limits.

The most problematic area in China is the CO_2 emissions and consumption of global hectares, which are clearly in an unsustainable state if strong sustainability criteria are used. Also, the biodiversity measured with forest area changes is in the non-sustainable area. Biodiversity measured with the amount of protected forest area organic farming are close to the limits of sustainability.

In the social development sphere, most of the indicators show sustainable development. The only problematic area here is the development of employment where real economic growth has not been able to keep up with the improvement of work efficiency reducing employment.

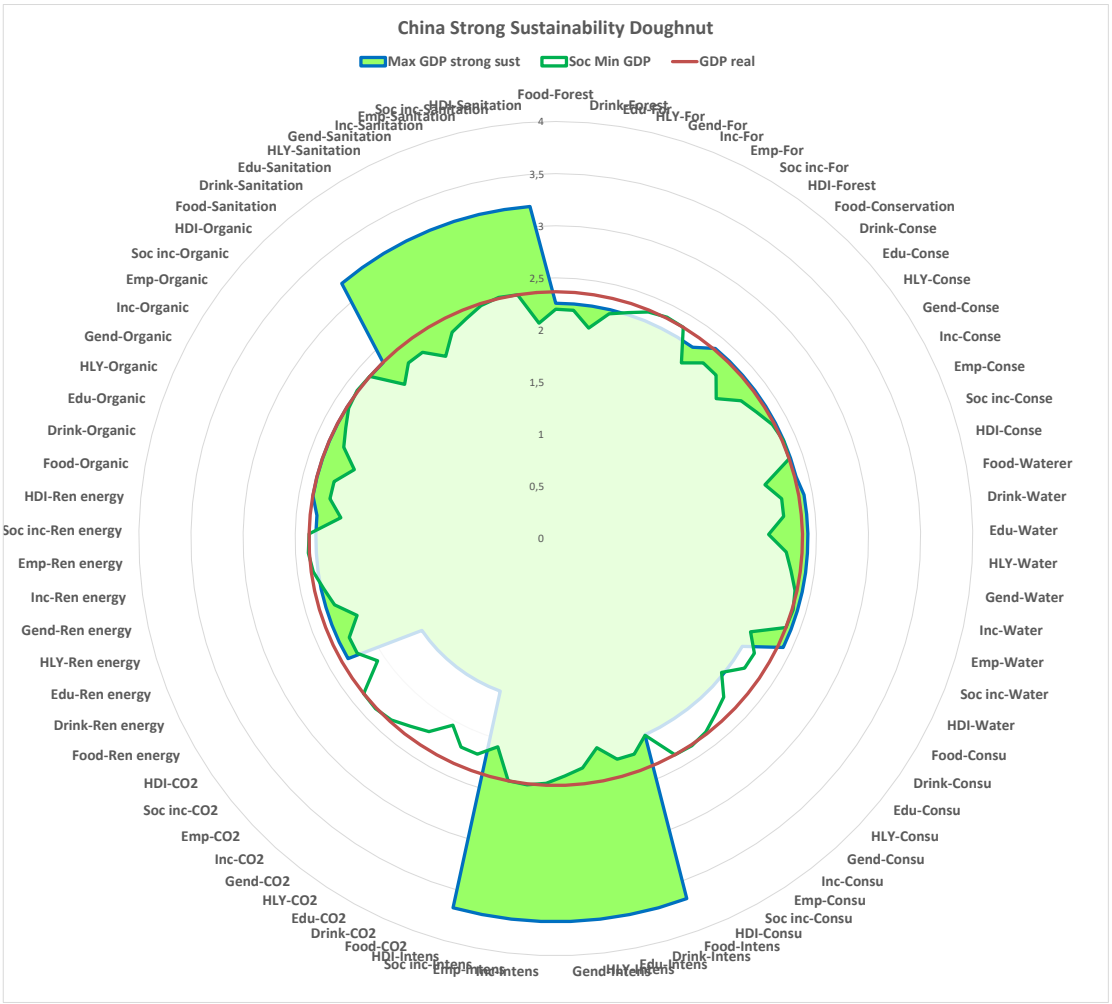

Figure 4. Doughnut Model for China for 2006-2016 using the indicators of Table 1.

A more detailed view of the maximum economic growth related to the environmental variables and the relation to real economic growth is shown in Fig 5. and the minimum

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economic growth related to social variables together with real economic growth is shown in Fig. 6.

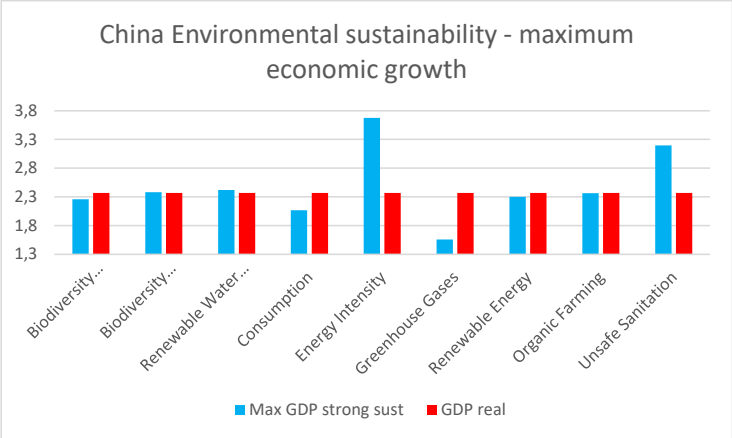

Figure 5. Maximum sustainable economic growth related to environmental limits (in Table 1) and real economic growth in China 2006-2016.

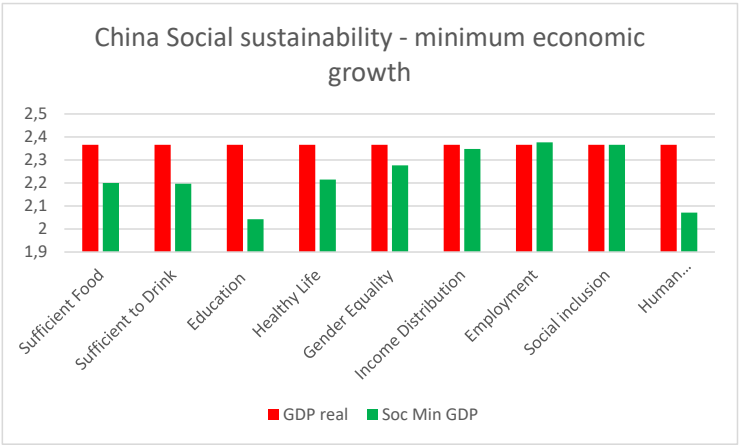

Figure 6. Minimum sustainable economic growth related to social limits (in Table 1) and real economic growth in China 2006-2016.

The doughnut Model for India is shown in Figure 7. India has performed well in relation to sanitation, energy intensity (savings), renewable water and forest conservation in the field of environmental sustainability. Also, consumption of global hectares, forest area and organic farming are within the sustainability limits. The most problematic area seems to be CO_2 emissions and renewable energy use.

In the field of social sustainability, India seems to be on the sustainability track related to several indicators; education, human development index, healthy life years, clean drinking water sufficiency, gender equality, food sufficiency and employment. Problematic areas seem to be income distribution and social inclusion.

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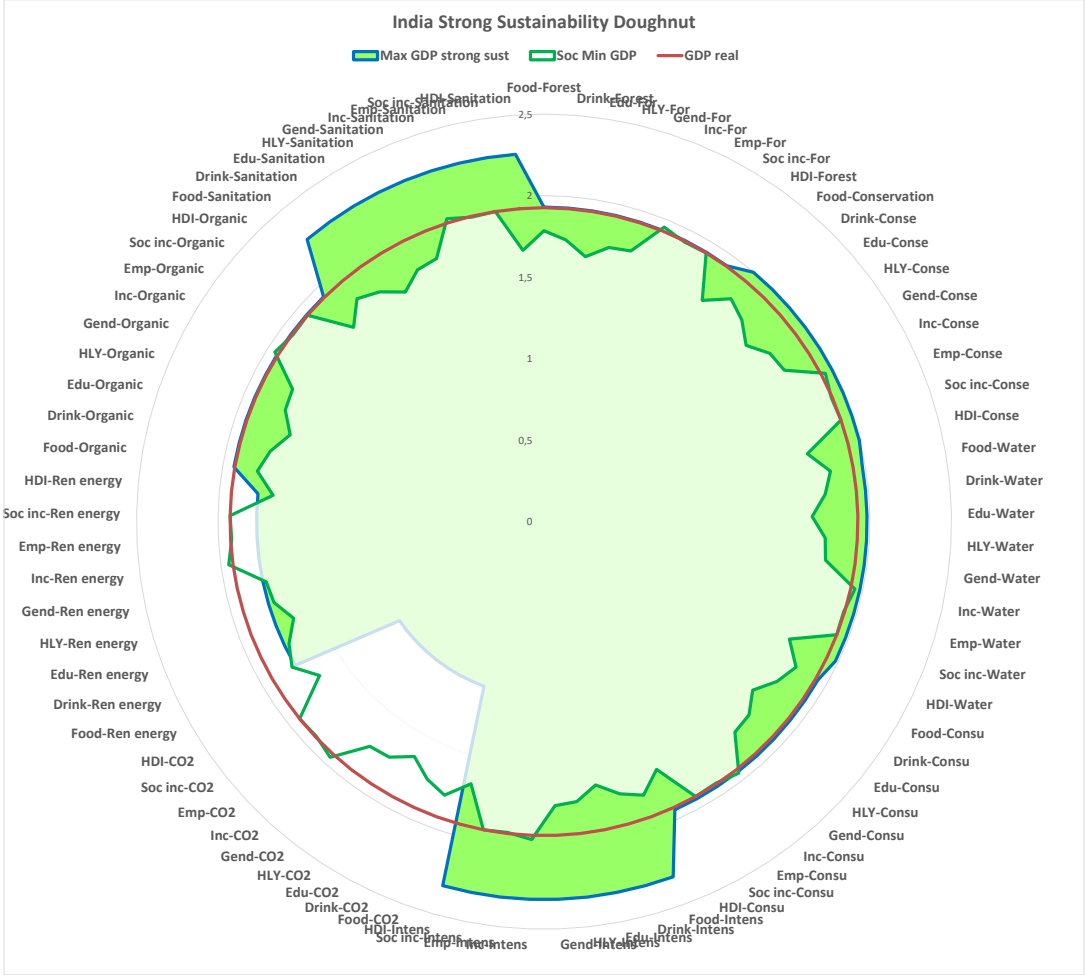

Figure 7. Doughnut Model for India for 2006-2016 using the indicators of Table 1.

A more detailed view of the maximum economic growth related to the environmental variables and the relation to real economic growth is shown in Fig 8. and the minimum economic growth related to social variables together with real economic growth is shown in Fig. 9.

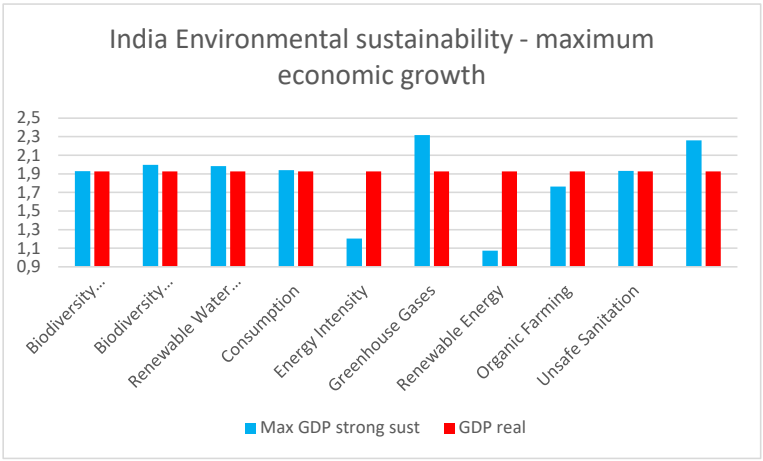

Figure 8. Maximum sustainable economic growth related to environmental limits (in Table 1) and real economic growth in India 2006-2016.

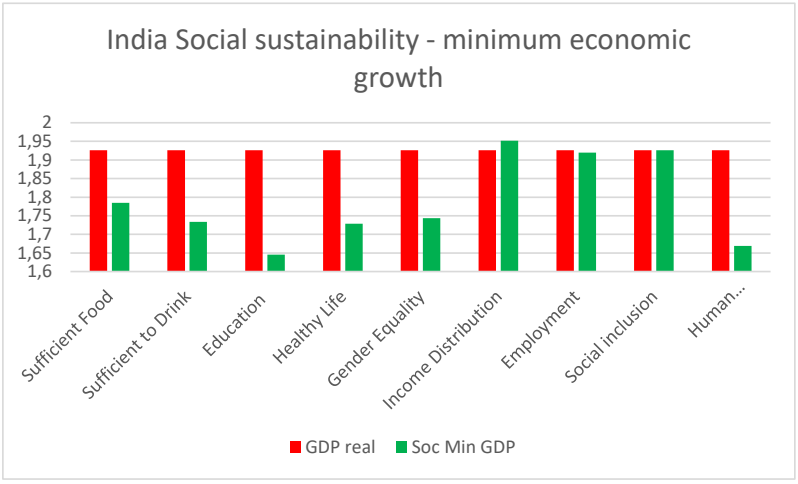

Figure 9. Minimum sustainable economic growth related to social limits (in Table 1) and real economic growth in India 2006-2016.

The strong sustainable Doughnut Model for the USA is presented in Figure 10. The USA has performed well in areas of reduction of energy intensity, CO_2 emissions, consumption of global hectares, conservation of forests and renewable energy use. Also, the forest area has slightly increased during the analysis period. Renewable water use as well as organic farming are problematic areas in the USA from the point of view of environmental sustainability when we look at changes from 2006 to 2016.

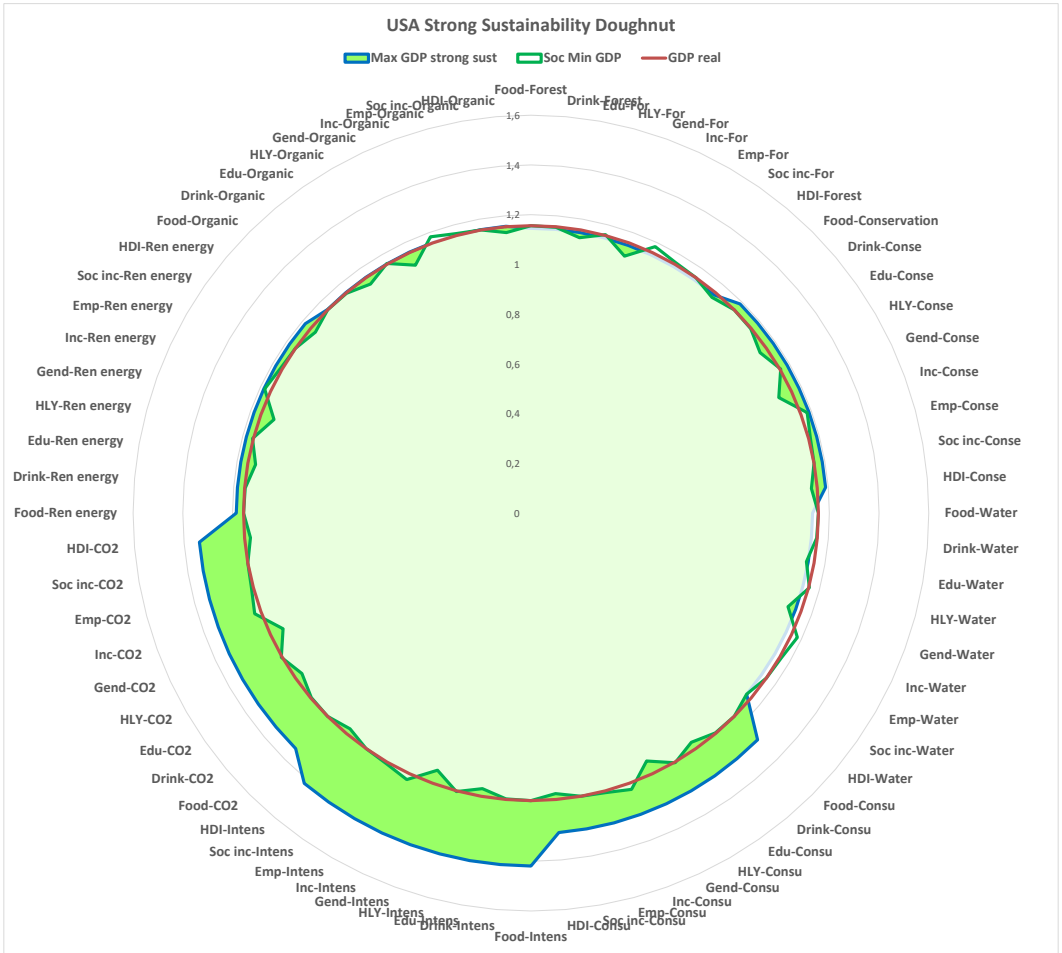

Figure 10. Doughnut Model for the USA for 2006-2016 using the indicators of Table 1.

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In the field of social sustainability, the USA has been successful in the areas of gender equality, education, the human development index and the sufficiency of clean drinking water. Problematic areas are income distribution, employment and healthy life years.

A more detailed view of the maximum economic growth related to the environmental variables and the relation to real economic growth is shown in Fig 11. and the minimum economic growth related to social variables together with real economic growth is shown in Fig. 12.

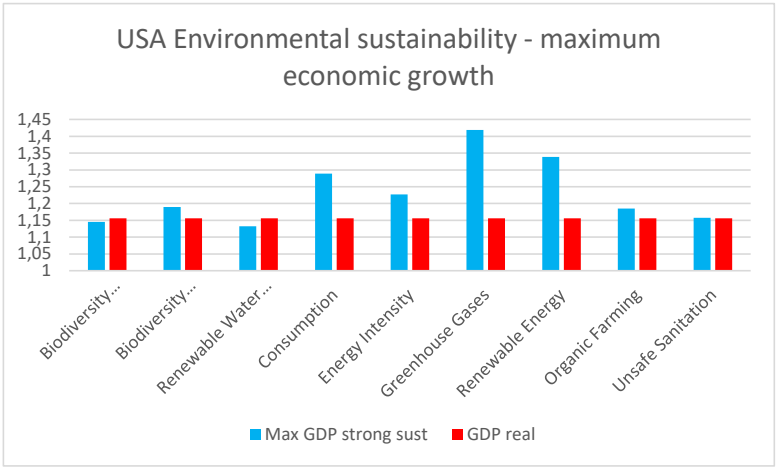

Figure 11. Maximum sustainable economic growth related to environmental limits (in Table 1) and real economic growth in the USA 2006-2016.

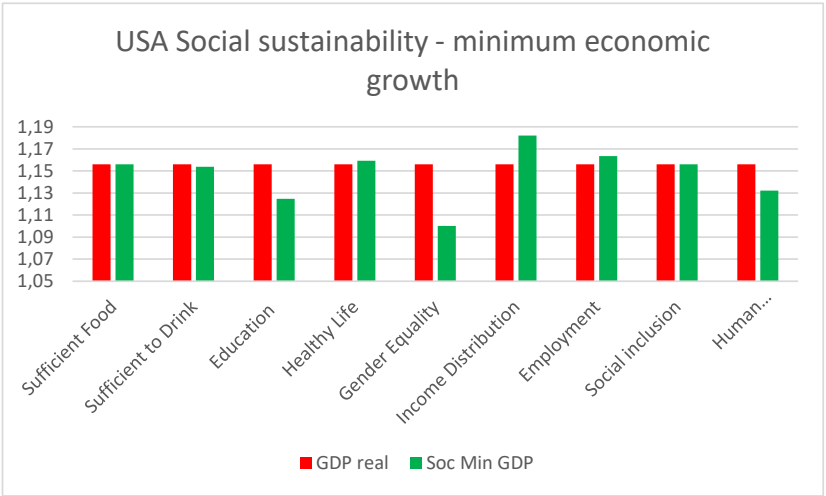

Figure 12. Minimum sustainable economic growth related to social limits (in Table 1) and real economic growth in the USA 2006-2016.

The Doughnut Model for Finland is presented in Figure 13. Finland has been successful in the reduction of CO_2 emissions, decreasing energy intensity, use of renewable energy, conservation of forests, renewable water use, organic farming and increase in the forest area. The problematic area in Finland is the consumption of global hectares which is related to the dependence and increase of foreign trade.

In the field of social sustainability, Finland has been successful in the areas of education, gender equality, the human development index and employment. Problematic areas are income distribution and healthy life years. Clean drinking water and food sufficiency have not been problematic in Finland.

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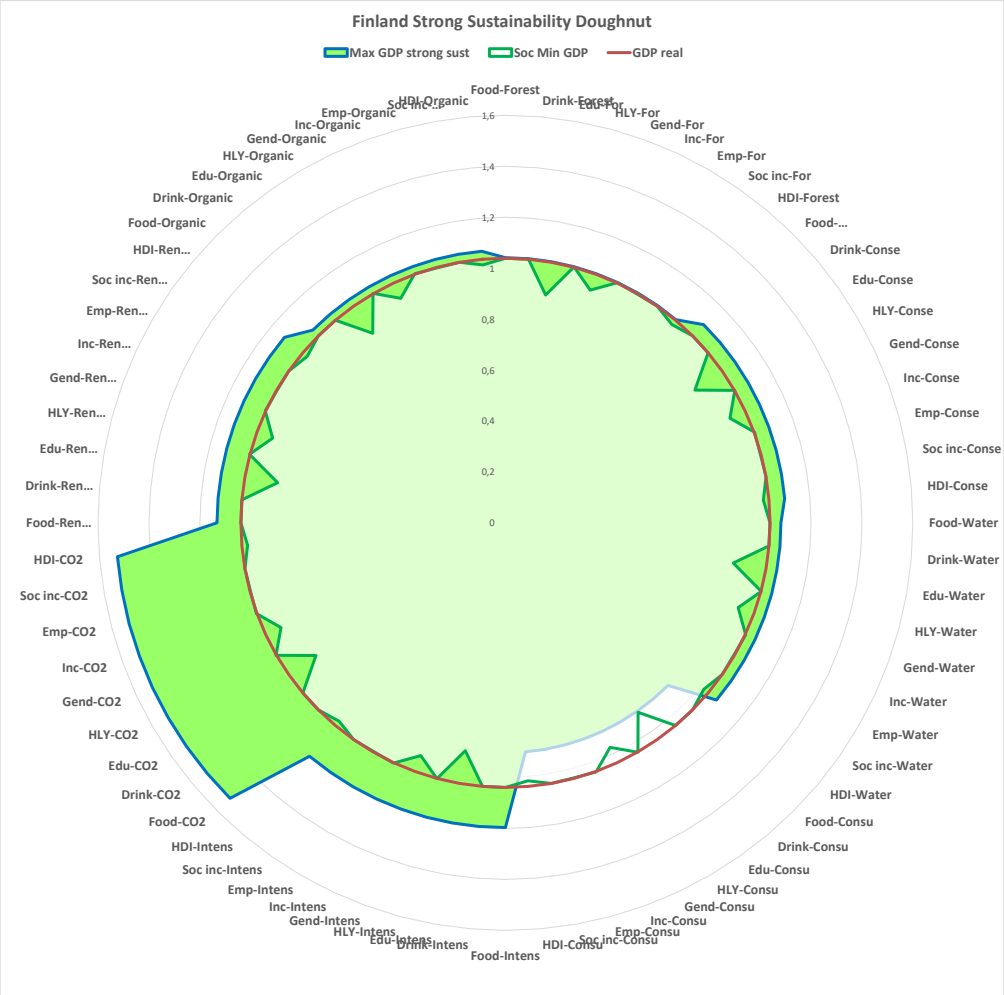

Figure 13. Doughnut Model for Finland for 2006-2016 using the indicators of Table 1.

A more detailed view of the maximum economic growth related to the environmental variables and the relation to real economic growth is shown in Fig 14. and the minimum economic growth related to social variables together with real economic growth is shown in Fig. 15.

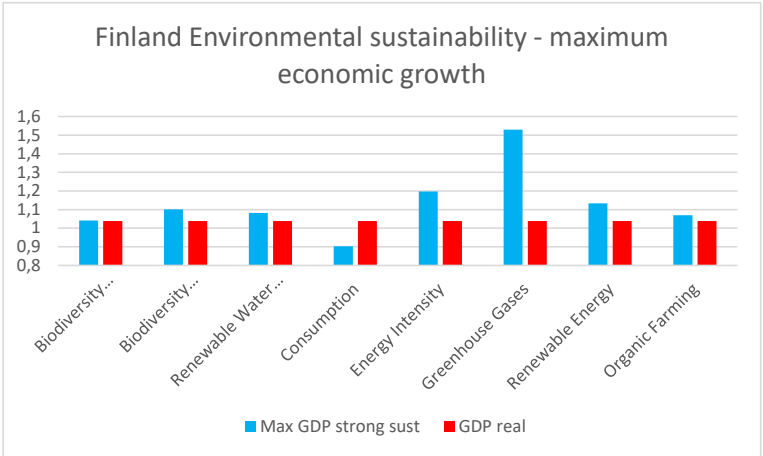

Figure 14. Maximum sustainable economic growth related to environmental limits (in Table 1) and real economic growth in Finland 2006-2016.

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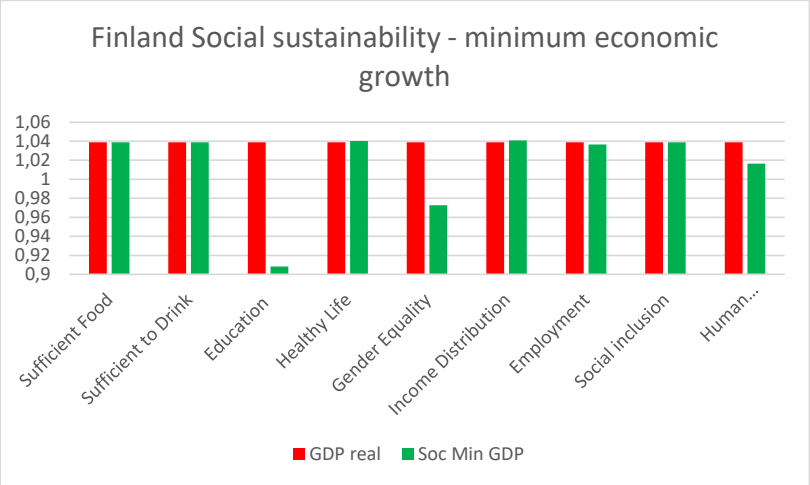

Figure 15. Minimum sustainable economic growth related to social limits (in Table 1) and real economic growth in Finland 2006-2016.

4 CONCLUSION

Sustainability Window (SuWi) method provides a novel tool for analysing sustainability simultaneously in the different dimensions, social, economic and environmental. It provides a firm basis for quantitative analysis of the development processes in these dimensions. The method makes it possible to use numerous different indicators for analysis of the development of different sectors and for looking at the interlinkages and synergies in the development. This can lead to more balanced policy planning. The method reveals the problematic areas related to sustainability and can be used for comparative analyses.

The SuWi method results can be used for Doughnut Model construction. The Doughnut models can be used for visualizing the sustainability results. It illustrated the area where sustainability targets are not met and further policy actions are needed. The SuWi method and Doughnut Model can provide important information for policy planning in an easily understandable form. They can be used as information tools for planning in different sectors of society and can communicate complex development problems.

The SuWi method can be used for trend analysis to provide important information on the directions of development processes. The trend analyses can be used as a basis for scenario construction and analysis of potential problematic development paths in different areas in the future. The results of dynamic SuWi analysis and scenario construction can be used for Doughnut Model construction for the future. This is important when policy planning is discussed with different stakeholder groups.

It is important to make a distinction between relative and absolute sustainability when the results of the SuWi method are discussed. The illustration of the difference between Indian and the USA's CO_2 emissions gives a concrete example of this. Climate policy has been geared towards the relative reduction of emissions from the base year level, but this omits the crucial point of the absolute levels of emissions. The SuWi method is well-equipped to use both relative and absolute targets for the analysis of sustainability. This is important when comparative analyses are carried out and the targets are set for sustainability.

FUNDING: The authors want to thank the Academy of Finland for funding the "Cuban energy transformation Integration of Renewable intermittent sources in the power system (IRIS)" project, decision n:o 320229.

CONFLICT OF INTEREST: Authors declare no conflict of interest.

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SDConference Proceedings 2022 ISBN: 978-86-87043-85-5

Sustaining Social Forestry for Sustainable Human Development

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Abstract

Forests have been a most important basis for human sustenance and overall wellbeing since ancient times in many intrinsically and immensely important ways. However, with rapid increase in human populations and their expanding activities and excessive exploitation of forest resources, forests across many parts of our planet have faced serious damage, depletion, destruction, and degeneration in various manifestations leading to severe negative consequences threatening the lives and livelihoods of people especially in fragile ecosystems. Such anomalies chiefly prevail in developing and underdeveloped economies and their least developed pocket areas.

As an attempt to cope up with various forest resource related constraints, to fulfill resource requirements, and to render living conditions easier, improved, and advanced, human communities have domesticated many tree, shrub and herb species of special utilities and their own choices through different social mechanisms. This innovative approach human societies adopted in the course of their gradual advancement led to the emergence of the concept and practice of social forestry in varied forms and for multiple benefits. Owing to its multifarious positive properties contributing to social, economic, and environmental dimensions of human life, it is gaining increasing popularity and coverage across all communities in the world and has already generated lots of valuable impacts on the whole. However, its coverage and richness are still limited. Besides, it is beset with constraints and problems of diverse dimensions and high magnitude.

Finding and effectively executing ways to mitigate the constraints and problems is indeed the great need today for all those concerned with the growth and development of social forestry. Just as its types and benefits are diverse, the requirements for its rapid progress are large and comprehensive. Provided concerted sincere efforts come in a cohesive, concrete and cordial manner from all stakeholders at all levels and of all categories and capacities, social forestry can contribute impressively to the basic pillars of sustainable human development – society, economy, and the environment. Prevalence of ensured full-fledged good governance in all spheres would be key to substantive success in this regard.

Keywords: Forest, forestry, social forestry, sustainable development, Nepal.

A. Forests in Human Development Perspective

A forest is an overall community of various types of trees, shrubs, and herbs growing in a certain area of land. It naturally embraces various kinds of animals, insects, and microbes as well. In fact, a forest comprises not only the various forms of flora and fauna but even such waterbodies as ponds, lakes, springs, waterfalls as its integral parts to form a complete forest ecosystem of vital resources and ambience. Humans have depended heavily on forests in numerous important ways (e.g., food, shelter, fibre, fire, seclusion, safety, security) right from the days he emerged on earth. This dependence will remain forever albeit in varying degrees and forms depending upon his circumstances, choices, and needs. Plants (herbs, shrubs, trees) nourish and influence human life throughout from the latter's conception till the end of life and even thereafter in the case of some cultures (Ojha 2018).

Realizing the usefulness and importance of plants (Maiti et al. 2014; Ojha and Rijal 2014; Shrikanth et al. 2015), people of all cultures and faiths in the world have regarded plants as gods and their community (forest) as their abode (Ojha 2018; WWF 1999). For instance, Rig Veda – the oldest scripture believed to have been composed as early as 1700 BCE and written not later than 300 BCE deeply recognized and acknowledged the varied important properties and values of plant resources (Shrikanth et al. 2015). Similarly, the Rig Veda advocated the protection and conservation of plants (ऋग्वेद (३।१।६): इन्धनार्थाय शुष्काणां द्रुमाणामवपातनम्). It advocated the use of only dead or dry tree parts as fuels and considered using green plants for fuel as a sin (Ojha 2018).

Vriksha Ayurveda (Skt. Vriksha = plant, ayu = life, veda = knowledge) – the ancient science of plant life – written sometime around 300BC deals with various aspects of growing and using plants for human wellbeing. It considered trees as one of the most prolific and potent sources of human welfare. *Taru Mahima* (Skt., taru = plant, mahima = praise) described plants as an immensely important source of ahara (= food) and aushadhi (= medicine) highlighted the value of plants to such a height as: one pond is equal to ten wells, one lake is equal to ten ponds, one human offspring (human life) is equal to ten lakes, and one plant/tree is equal to ten human lives (Srikanth et al. 2015). In Hinduism, many plants are worshipped as are the sun, the moon, rivers, lakes, air and water. The plant species revered the most chiefly include pipal tree (*Ficus religiosa*), banyan tree (*F. bengalensis*), golden fig (*F. benjamina*), and sacred basil (*Ocimum sanctum*). *F. religiosa* is in fact regarded as vriksha-raja (Skt., king of trees) and deeply revered and regularly worshipped using the following mantra: *मूले ब्रह्मा, त्वचे विष्णु, शाखायां श्री महेश्वरः । पत्रे-पत्रे स्थिता देवाः, वृक्षराज नमस्तुते ।।* [Skt., Prayers to Vriksha Raja (the king of trees) harboring Brahma in roots, Vishnu in bark, Maheshwar in branches, gods in each leaf!]

Leaves of many plant species, including pipal, and others such as mango (*Mangifera indica*), sacred basil are essential requirements in most rights and rituals (Ojha 2018). Logs of several species of trees are needed in certain major religious events to prepare chariots of deities, install merry-making swings, and perform yajna (sacrificial ritual fire), aesthetic, ecological/ environmental and socioeconomic benefits apart (OFRI 2018; Ojha 1980, 1985).

B. Forest Resources and Their Importance

Forest resources include a variety of flora and fauna living in integration with one another in the forest ecosystems. Land, soil, and water are naturally the integral components of these ecosystems. The survival and prosperity of mankind is dependable and largely influenced by changes in these. A better understanding about their value is undoubtedly of great importance for all concerned with others' as well as their own wellbeing that relies in the proper management of the forest ecosystems in general and social forestry in particular. Therefore, hereunder the major benefit potentials of forest resources are summarized (e.g., Table 1), with focus on their economic potentials (especially in the Nepalese context). It may also be pertinent

 ISBN: 978-86-87043-85-5

at this juncture to describe their other services that do not directly appear to be of economic value, but can be accounted through specialized techniques of evaluation devised in recent years (e.g., the willingness to pay technique).

Table 1: Summary of the Major Beneficial Features of Forest Ecosystems

Letter	Attributes/representation
F	Food, fodder, fibre, firewood, furniture, fruits, fertilizer, fuel, friendship, fragrance, freshness, filtration, fulfilment, freshness, fortitude
O	Oxygen, oil, ointment, ornamentation, organic matter, oleoresin
R	Rain, rattan, resin, renaissance, rubber, recreation, roofing material, roughage
E	Ecosystem, energy, environment, employment, erosion control, entertainment, endurance
S	Shelter, soil nutrients, sap, sleeper, sericulture, shipbuilding, sports (goods), storage systems, scaffolding, stakes, sticks, stilt, serenity, scenery, sanctification, solitude, sanctuary, salvation, satisfaction
T	Timber, tourism, trade, tool handles, transportation, turpentine, thatch, treasury, tranquility.

Adapted from and expanded over: Ojha, 2003.

The fundamental services that forest ecosystems and resources offer to mankind can be very broadly categorized as their three major functions as mentioned below:

1. *Protective functions*
   Protection of soil from runoff/erosion by wind and water, and from excessive solar radiation exposure;
   Conservation of soil moisture and water holding capacity of the soil;
   Protection of beneficial microbes and insects in the soil, thus facilitating the maintenance of better structure, texture and productivity of the soil.
2. *Regulatory functions*
   Absorption, storage and release of carbon dioxide and oxygen gases and micro and macro mineral elements
   Absorption of aerosols and noise
   Storage and release of ground water
   Absorption and transformation of radiant and thermal energy.
3. *Production functions*
   Storage of energy in the form of floral and faunal biomass.
   Production and regeneration of products such as leaves, wood, fruits, buds, flowers, bark, and roots.
   Production of large variety of chemical compounds such as resin, alkaloids, essential oils, latex, dyes, and pharmaceuticals.

The numerous beneficial services (director/and indirect economic importance) of forest ecosystems and resources can be delineated perhaps more elaborately and clearly as follows:

1. *Ecological effects*
   Catchment protection – runoff control, water supplies, irrigation, soil fertility, oxygen
   Carbon sequestration
   Ecology and wildlife conservation – recreation, tourism, national parks, protection of endangered species of flora and fauna
   Soil erosion control – windbreaks, shelter belts, dune fixation, eroded land reclamation

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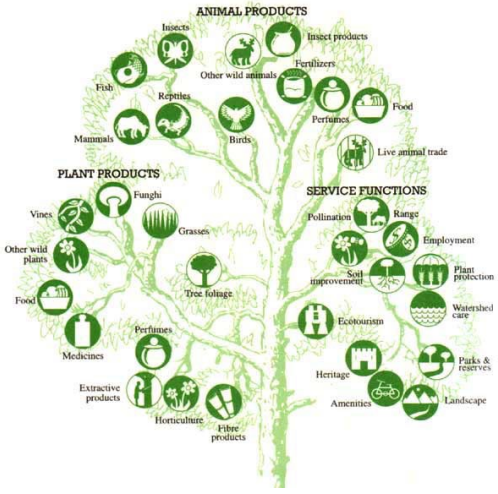
2. *Indigenous consumption*
   Fuelwood and charcoal – cooking, heating, and other household uses
   Agricultural uses – shifting cultivation, forest grazing, nitrogen fixation, mulches, fruits and nuts
   Building poles – housing, building construction, fencing, furniture
   Pit-sawing and sawmilling – joinery, furniture construction, farm buildings
   Weaving materials – fibre, ropes, strings, baskets, furniture, furnishings
   Sericulture, apiculture, sericulture – silk, honey, wax, lac
   Special woods and ashes – carving, incense, chemicals, glassmaking
   Hunting for bush meat
3. *Industrial uses*
   Gums, resins and oils
   Charcoal
   Poles, e.g., transmission poles
   Saw-logs – lumber, joinery, furniture, packing, shipbuilding, mining, construction, railway sleepers
   Veneer logs – plywood, veneer furniture, containers, construction
   Pulpwood – newsprint, paperboard, printing and writing papers, containers, packaging, dissolving pulp, distillates, textiles and clothing
   Residues – particle board, fibre board, wastepaper.
   Hides, bones, furs, wool from wildlife (Ojha 2003).

Figures 1 and 2: Reflection of Multifarious Positive Properties, Products, and Services of Forests



Source: Wikipedia, October 2018.

Forests are crucial determinants of the accumulation of greenhouse gases in our atmosphere. They absorb 2.6 billion tons of CO_2 (carbon-dioxide) each year, about one-third of the CO_2 carbon released from the burning of fossil-fuels. Clearly, therefore, destruction of forests has large negative impacts. Deforestation accounts for almost 20 percent of all greenhouse gas emissions — more than the world's whole transport sector. While being critical to slowing, lowering or even halting climate change, forests are important for reducing the present and future climate change impacts on people. For instance, forest products are more climate-resilient than traditional agricultural crops and when disasters hit and regular crops fail, forests act as safety nets to save communities from losing all sources of food and income (CIFOR 2018).

 ISBN: 978-86-87043-85-5

Forest lands provide a source of micronutrient rich food for millions of people around the world. These foods may be of great value to the dietary quality of people living in close proximity to forests – especially in communities with poor access to markets (Rowland et al. 2017). Clearly, therefore, we must devise and dispense better forest management mechanisms for increasing and improving forest cover in the world to check climate change and improve the overall environment and people's lives (CIFOR 2018).

C. Forest Resources Status in Nepal

Nepal is one of the few countries of the world that depend extremely largely on forest resources for various production and productive purposes. More than 75 per cent of the country's energy requirement is fulfilled from fuel-wood that comes largely from forests, shrub lands, and the lands adjacent to farms. In rural areas, almost all households rely on forests for firewood for cooking and heating purposes. Similarly, 40 per cent of the livestock nutrition (fodder) is fulfilled from forests. Besides, nearly all the timber used comes from the forest. Forests maintained as national parks and wild life reserves serve as reservoirs of genetic resources and contribute to tourism. For example: the total revenue Nepal generated from its forests in the fiscal year 1996/97 was about Rs. 320 million, out of which approximately Rs. 268 million was from the sale of timber alone. Export of medicinal herbs exported in that year was worth more than Rs. 12 million and the handmade paper and its products worth as much as over 59 million rupees. The other major products exported included catechu, incense sticks, and wooden and bamboo goods.

The share of forestry in AGDP is about 10 per cent. If complete accounting of the multifarious services provided by forests could be made, such share would appear much higher indeed. Especially the hill farming system of Nepal depends highly on the forests for fuel, organic matter for crops, and animal feeding and bedding. Shepherd (1985) estimated that 3 hectares of forested land is needed to support 1 ha of cultivated land. Gilmour and Applegate (1986) however suggested that 6 hectares of forested land is required for each hectare of cultivated land in the hills (Ojha 2003). The total forest land covers about 5.83 million ha which is 39.6% of the total land of the country. This includes 29 percent with dense forest and remaining with shrubs (NK 2017).

Once known as the chief wealth of the country (covering nearly 70 per cent of its area until about 60 years ago), it has declined rapidly over the recent decades. Over a period of twelve years until the early 1990s, a total of 99,000 hectares of forests were lost, at a yearly rate of 1.3 per cent. In about two decades between 1978 and 1998, 1.3 million ha of forest was lost. That accounts to over 67 thousand ha of forest cover lost annually. The annual rate of loss for that period is thus about 1.26 per cent.

The worrisome rate of loss continues today, especially with regard to the crown cover, which in several ways is a most important aspect of the forest. As of recently, forests with 70-100 per cent crown cover comprised only about 15 per cent of the country's total forest areas.

Most of the forest depletion has taken place in Terai, and now only about 8 per cent of the country's natural forests remains in this zone. The large-scale depletion in the Terai and Doon valleys occurred during the mid-1950s. The main causes were settlements for political sufferers, victims of natural calamities, expatriate immigrants, and at a later stage, rapid migration from the hills as malaria was eradicated and new production frontiers opened in those lowlands. The loss has been less in mountains and hills compared with the Terai. However, in the middle hills, where the population density per unit of arable land is very high, the deterioration is much severe.

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D. Use Potential of Forest Resources

Product supply
Major and minor products: timber from trees of varying usage and value); and non-timber forest products (NTFP) such as grasses, herbs, bark, bamboo, ropes, wildlife

Service benefits
Water supply, recreation, climatic regulation, aesthetic importance
Income and employment generation
Employment for skilled and unskilled workers
Rural households can derive a variety of products for consumption and sale
Processing of products to produce and sell high-value products

Contribution to other sectors
Import substitution and local/national saving
Input/energy for various processing, curing industries
Input for agricultural production/productivity
Protection/regulation of water supply
Preservation of wildlife sector
Contribution to tourism, housing and construction

Contribution to the country's balance of payment situation
Export of products for foreign currency earning and improving the balance of payment situation

Environmental contribution
Conserving soil and water
Protecting floral and faunal wealth (parks, reserves)
Regulating/improving the hydrological situation/status (enriching the watersheds/catchment areas)
Carbon sequestration
Protection of man, animals and delicate plants from direct and intense solar radiation in high mountain areas
Protection from dust and wind blows and flood damage by creating shelterbelts and windbreaks
Controlling air, noise and water pollution to improve human and livestock health and the environmental situation

E. Utilization of Forest Resources in Nepal

Production uses
For construction purposes:
In absence of modern types of construction materials such as steel, iron, cement, and glass, timber, poles, bamboo, ropes and other materials from forests were extensively used and are being used substantially even now.

For consumption and commerce:
Numerous other plant-based and animal products were derived for household uses as well as for export and sale within the country. These basically comprised fuel, fodder, medicines, spices, gums, resins, animals and animal products (bush meat, hides, bones, and fur). Many of these are being extracted also these days.

For infrastructure building: for example, in roads, high-tension electrical transmission lines, irrigation canals.

For soil and water conservation (watershed protection): being practiced now and will/should continue in the future.
For hunting, recreation, and tourism purposes: some revenue from hunting fees seems to have been generated annually till fiscal year 1988/89.

Some other production uses/misuses
Rulers exploited forests recklessly for building their personal and family wealth and assets through export of valuable timber and fauna.
Some resources were misused by the followers/supporters of the rulers.
Sometimes such resources were used for meeting public expenditures, too, such as social and physical infrastructure building.
The Tarai and Doon valley forests were exploited severely by some government agencies and influential people, private logger/sawmill owners/timber traders, poachers, and smugglers (Ojha 2003). Such activities, besides the destruction of natural forests in the names of development and construction projects, continue to take place till the date unfortunately (Kantipur 2018; Ojha 2018).

Use of the protective and regulative functions
Conservation of watershed areas to maintain the sources of water and soil.
Protection/ornamentation of farmstead/house premises.
Protection of gullies and streams by planting trees, bamboo, agave.
Leaves as litter and manuring substance.
Transhumance process and the grazing of livestock.
Protection and ornamentation of canal and riverbanks is a rather new trend.
Preservation of the environment around sacred places, farmlands, and village/hamlet peripheries.

The above facts reflect precisely that forest resources can contribute greatly to the economy of the country in many different ways, besides offering various non-economic services. Owing to inadequate and some inappropriate forest management systems/ arrangements, however, the economic and environmental potentials of forest resources have either been misused or underutilized in the country.

F. Forestry – Definition and Dimensions

Forestry can be defined as the theory and practice constituting the creation, conservation and scientific management of forests and the utilization of their resources. It includes all thoughts and actions pertaining to creation and management of forests, including harvesting, marketing and utilization of all forest products and services. It not only encompasses the management of existing forests but also the creation of new forests. Based on the objectives for which forestry is practiced, it can be classified into protection forestry, production forestry, and social forestry as briefly described below.

Protection forestry entails the practices of managing the forests for their protection function. Clearly, its objective is to protect the site from instability of terrain, nature of soil, and geological formations, for instance. Forest areas whose manipulation is not desirable may be classed as protection forests. The forests located on higher hill slopes, national parks and sanctuaries, preservation plots, biosphere or nature reserves and wilderness areas may be included in this type of forestry. On the whole, it is the practice of forestry aimed at conserving flora, fauna, soil and water, increasing water yields, reducing floods and droughts, and amelioration of climatic conditions.

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Production forestry is **t**he system of forestry that has the prime objective of producing maximum quantity of timber, fuel wood and other forest produces. It can be further categorized into: commercial forestry (aiming, as an enterprise, at obtaining maximum production of timber, fuel wood and other forest products), and industrial forestry (meant for producing raw-materials required for use in an industry) (Wikipedia, 2015).

G. Social Forestry – Basic Features and Benefits

It is a practice of forestry aimed at meeting the requirements of rural and urban population by meeting their basic plant resources based needs to ease and improve their living conditions chiefly through supply of the following goods and services of great value to local inhabitants and overall human life:

i. Supply of fresh food, fruits, flowers, fiber, fuel-wood, fodder, pulp, oil-seeds, and timber at home or locally (Ojha 2003, 2018; Rowland et al. 2017; Jamnadass et al. 2015);
ii. safety net for supply of cooking fuel in cases of cooking gas supply blockage or shortage;
iii. protection of agricultural fields against heavy rains, wind, floods, erosion, and slides;
iv. recreation, medication, seclusion/solitude, rejuvenation, sentimental gratification;
v. parts of farm-tools and implements (e.g., handles), hooks, sticks, stakes, stilts;
vi. increasing the self-sufficiency of local people for essential forest products;
vii. leaves and litters as inputs for composting / farmyard manure;
viii. conservation of soil moisture and plant nutrients;
ix. absorption of CO_2 (carbon-dioxide) (CIFOR 2018; TEMPO 2016; Ojha 2003);
x. reduction in pollution from dust, dirt and smoke, and noise;
xi. increased possibilities for induced rainfall and balanced humidity and microclimate;
xii. providing shelter for beneficial and beautiful fauna (e.g., birds, bats, butterflies);
xiii. raising the level of underground water;
xiv. reduction in the drudgery and time spent fetching drinking water from far;
xv. raising momentum for collective work and self-help for mutual benefits;
xvi. increased production and increasing farm returns (Dongre 2011; Ojha and Rijal 2014; Ojha 2018; Wikipedia 2015);
xvii. forest land and resource use constraint related conflicts can be reduced (TR 2017);
xviii. improving child nutrition through supply of nutritious forest produce (Ickowitz et al. 2016);
xix. protection and productive use of fallow and wastelands around human settlements;
xx. beautification and freshening of physical and social surroundings;
xxi. support for various climbers of vegetables and fruits;
xxii. supply of raw-materials for art and craft, thus contributing to economic and aesthetic advantages;
xxiii. providing scope for physical exercise and mental gratification at home and around;
xxiv. generation of employment opportunities at home and around locally;
xxv. increased mass awareness about the benefits for forestry and skills in forestry;
xxvi. enriched clean and fresh overall local environment in particular and global one in aggregate;
xxvii. reduced pressure and people's excessive reliance on natural forests, reduction in their encroachment, excessive exploitation, destruction and depletion, thus eventually leading to their regeneration, recovery and enrichment for multiple overall economic and environmental benefits for all in various ways and extents.

As reflected at the outset above, social forestry is an ancient practice adopted by people as early as they started living in societies in close proximity to and integration with various types of plants and animals for multiple purposes. In the course of creating organized, clustered settlements or scattered dwellings to live in, people domesticated many useful plants and animals and made use of them in numerous beneficial ways. With diminishing access to and availability and constraints of natural forests owing to varied factors, people facing paucities of forest resources and benefits thereof created mechanisms to cope up with the situation and fulfill their specific requirements of forest resources and benefits. This gave rise to the various systems of social forestry.

Social forestry thus supplemented the supply of forest goods and services and filled up the resource availability and usage gaps and emerged in diverse forms and patterns depending upon people's specific needs, choices and circumstances. On the whole, taking the pressure off the natural depleting forest and making the best use of fallow and wastelands is the most common purpose of the practice of social forestry, although it goes much beyond this purpose.

Although sparingly and informally in practice for long, social forestry emerged – distinctly in the form of Community Forestry in late 1970s globally as well as in countries like Nepal. It gained popularity chiefly due to the failure of industrial development model to bring about people's socioeconomic development, and also due to the rising problems of severe deforestation and land degradation and consequences in many parts of the world. The community forestry concept and practice gained popularity especially after the FAO published its report entitled Forestry for Local Community Development. They got further consolidated thanks to the Forestry for People theme of the Eighth World Forestry Congress held Jakarta, Indonesia, in 1978 (Koirala et al. 2008).

In late 1990s, experts estimated that some 200 million hectares of new trees would have to be planted during ten years then if developing countries were to meet their people's needs for tree products. If those plantings were done on a commercial basis, the investment needed would be at least US$100,000 million. Much of that investment would be needed in the countries least able to afford it. The governments of those countries would not be able to finance all, or even most, of the necessary work, even with foreign or international support. Thus, much of the tree planting would have to be done by the beneficiary communities themselves. Local community participation is vital in large-scale forestry.

New information and innovative approaches are essential to develop and dispense education and training for foresters and others who would need to stimulate and guide forest development by people through expanded social forestry measures (Gregersen et al. 1989). Production, distribution and use of such awareness, information, knowledge, skills and techniques have not been sufficiently and effectively disseminated to related individuals and institutions especially in countries and communities where they would be mot required and beneficial.

The most distinguishing characteristic of social forestry, in contrast to industrial and large-scale government forestry, is the involvement of local - generally rural - people in developing, maintaining and utilizing forests by, for and of themselves. Social forestry is usually difficult to identify, as it seldom involves large blocks of trees or 'forests.' Instead, it involves a few trees here and a few trees there, a small village woodlot, trees along the road or interspersed in the fields. However, in aggregate these small-scale activities by millions of planters across settlements of countries in the world can be significant (Gregersen et al. 1989). In that perspective, the sphere of the types of social forestry is naturally deeper and wider to encompass such interesting and important plant community management systems as urban forestry (e.g., parks, tree platforms, gardens, road- and street-side planting, roof-top forests/gardens, homestead forests), and special rural forestry (e.g., tree platforms, sacred sites/shrines, public gathering sites, orchards, homestead forests).

 ISBN: 978-86-87043-85-5

H. The Major Types of Social Forestry

Social forestry can be broadly classified into the types each described below in brief:

Community forestry:
It is the forestry done on lands outside conventional forest areas for the benefit of local communities of people. As indicated by its name, it involves the community people in its creation, management and utilization.

Farm forestry:
It is the forestry practiced on agricultural farms of village lands and is generally integrated with other agricultural operations. In this system, individual farmers plant trees on their own farmland to meet the domestic needs of the household. Shade for certain shade-loving plants such as cardamom, creation of shelter belts and wind-breaks to reduce the flow of wind and sand and thus reduce soil erosion and conserve the land constitute most common practices in this system.

Extension forestry:
It encompasses activities of raising trees on free spaces of farm lands, wastelands, barren lands, community forest areas, sides of trails, roads and railways, and banks of canals, rivers, ponds, lakes, office premises.

Agroforestry:
It is a sustainable land management system that integrates the production of crops and forest plants and/or animals simultaneously or sequentially on the same unit of land and uses management practices compatible with the cultural practices of the local population and can substantially increase crop yields from the land used.

Recreation forestry:
It is the forestry system adopted to develop and maintain forests of high aesthetic/ornamental/scenic value. This is mainly practiced in towns and cities and is of late catching increasing popularity. In this forestry system, flowering trees, shrubs, herbs and creepers in particular are planted and maintained in various ways to create a lively and lovely ambience of forest.

The other various types of social forests include homestead forest (maintained within private home premises), peripheral planting (done along the margins of a farm land), block farming (plantations done in small blocks / areas of land), riparian buffers (around water bodies such as a lake), shelter belts (plantations done to harbor specific beneficial insects and birds, and plants), wind breaks (trees grown perpendicular to the usual direction of wind to slow its velocity) (Jain 2015), plantations in institutional premises (e.g., academic institutions; libraries; playgrounds; hospitals; government, corporate and private offices).

J. Select Examples of Large-scale Social Forestry

Nepal's forest categories in management perspective are broadly: Government managed forest (GMF, national forest), community forest (CF), leasehold forest (LF), religious forest (RF) and national parks and reserves (NPR, protection forest). Most Terai forests are categorized as GMF. Forests of Terai districts are chiefly considered as productive forests. Forests in hill districts are managed through the Community Forestry Program (CFP). Initiated in 1978, CFP is the highest priority program in the forestry sector of the country. Its objective is to manage all the accessible forests through active participation of the local communities (Wikipedia 2018).

A community forest (CF) in Nepal is defined as any national forest or part of the national forest that is handed over to a community forest users' group (CFUG) to develop, conserve and manage, extract, exploit, trade and/or distribute the forest products by fixing the prices independently, according to an approved operational plan. To form a CFUG, first a user group must be established and registered in the related District Forest Office (DFO) along with their constitution (Pathak et al. 2017).

CFP has become a most renowned participatory forest management scheme in Nepal. As of 2011, a total of 2.1 million households (about 40% of national total) through 17,685 Community Forest User Groups (CFUGs) were managing about 1.6 million ha (27.4% of national total) of national forests as community forests. Another form of participatory forest management system aimed at improving the livelihood of poor people is Pro-poor Leasehold Forestry. There are about 6,712 Leasehold Forest User Groups in the country and they cover about 62,735 households managing a total of 38,997 ha area of the national forest.

Collaborative Forest Management is another form of participatory forestry management scheme developed in Nepal aiming at managing forests in a collaborative manner approach jointly with key stakeholders (e.g., local forest users, local government and state forest authority). There are 15 such CFM in eight of the Terai districts which cover an area of 39,457 ha.

Recent studies on the 20 Terai districts by MFSC indicated the rate of forest cover increasing with an annual rate of 0.06% during 1990/91 to 2000/2001. Several, micro level studies and visual interpretations also have also shown that Nepal's forest cover and condition is significantly improving over the decades due to the Community Forestry intervention in particular. A study on seven hill districts showed that household incomes over the years 2003 and 2008 increased substantially amongst the community forest users.

Deforestation, degradation and fragmentation of wildlife habitat and biotic pressure in the remaining forests of the country continue to pose threat to effective biodiversity conservation. To address the problem, some protected areas have been maintained: 10 National Parks, 3 Wild Life Reserves, 6 Conservation Areas, 1 Hunting Reserve and 12 Buffer Zones in and around Parks/Reserves which cover an area of 34,185 sq.km (23.3% of total area of the country).

Whereas the Ministry of Forests and Soil Conservation (MFSC) is the lead government ministry for the planning and management of national forests in Nepal, other key stakeholders include civil society, NGOs, communities, private sector and donors (NK 2017).

Community-based forestry management in Nepal has yielded multiple positive results to a large extent: e.g., increased local jobs, improved farm productivity/production, rehabilitation of degraded forests and lands, increased supply of forest products, increased incomes from sale of forest products, protection of endangered species of flora and fauna, and overall improved welfare and wellbeing of the local communities (Pathank et al. 2017).

Community-based-forest-management mechanism has been an exemplary case of Nepal's advances in forest and biodiversity management and rural development. It is the second largest and mainstream forest management system after government-managed forestry. Nepalese local communities are now managing about one-third of the country's forests, and the area under their protection has tripled in the past two decades. Thanks to the community-based forest management forest the overall degradation and loss has declined significantly and even reversed at many areas, especially the mid-hills. The community forestry program has increased forest cover rapidly to help maintain the ecological balance in Nepal to a substantial extent. The program has also contributed to some reduction in poverty and improvements in social development activities. The community-based natural resource management system appeared relatively more resilient even during the political instability situation in the country.

 ISBN: 978-86-87043-85-5

When other institutions and processes faced crisis and failure, the community forest groups continued to protect their forests and other natural resources (RRN 2012).

In Table 2 below, a few exemplary cases of social forestry systems mainly across the various countries of Asia have been listed. A revisit to and updates on these would indeed generate a useful set of information on and insights into their successes or/and failures as fruitful lessons to make use of in future endeavors for social forestry development programs.

Table 2: Some of the Exemplary Large-scale Social Forestry Schemes (mainly from Asia)

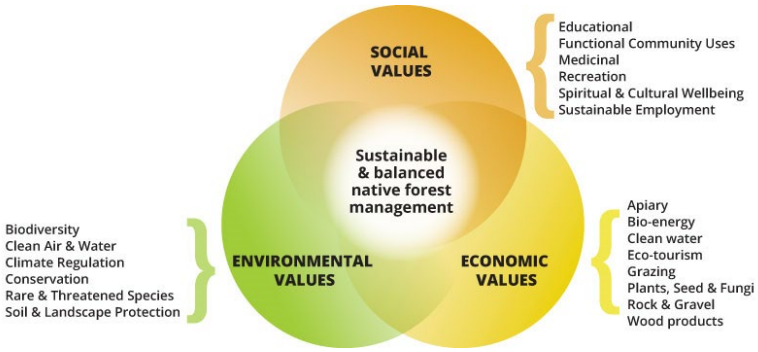
Scheme	Location
Community Forestry Program	Nepal: e.g., Mahalaxmi CF, Lalitpur, Nepal)
Social Forestry Program	Indonesia: Lampung, Kalimantan and Maluku
The Chipko Movement	India: Uttar Pradesh
Protected rainforests / sacred groves	Nigeria: Oshogbo
Community Fuelwood Programs ('Greening of Korea')	The Republic of Korea
Phewa Lake Watershed Improvement Program	Nepal: Pokhara
Upland Agriculture and Conservation Project	Indonesia: Java
Trees and Soil Fertility	Indonesia: Sitiung, West Sumatra
Using Trees to Control On-Farm Soil Erosion	Indonesia: Sikka district, Flores
Expansion of a Smallholder Tree-Farming Project	The Paper Industries Corporation (PICOP), and the Development Bank of the Philippines
Making Use of Marginal Lands ('four-side' or 'all around' planting program)	People's Republic of China
Communal Tree-Farm Program (CTF)	The Philippines
Integral Taungya and the Forest Village Approach	Thailand

Extracted from: Gregersen et al. (eds.) 1989.

K. The Prime Issues and Problems of (Social) Forestry Management

Understanding the conclusive issues and overcoming the related problems are needed for proper management of forests in Nepal in particular and in some other Asian and African countries in general. This could be helpful in materializing the policies, strategies, techniques, rules, and regulations, that are already in place, for improvements in situations where degraded/degrading/depleting/degenerating forest resources/sector are prevailing. That would eventually contribute substantially to achieving the goals of sustainable human development, as both forests, including social forests, and sustainable development share the same major dimensions – economy, environment, and society, and aim at their most favorable condition and mutual integration.

Figure 3: Major Dimensions of Sustainable Development | Figure 4: Broad Contributions of Forests



Source: Wikipedia, October 2018.

 ISBN: 978-86-87043-85-5

In the case of the massive and the overall substantially successful and popular Community Forestry Programme, a variety of shortcomings have surfaced over the years and yet without any timely solutions received so far. Such flaws chiefly include: elite dominance over decision-making, management affairs and benefit sharing; low participation of and benefits to poor sections of the society; poor people's low or no access to subsidized forest products such as timber for lack of financial means; boundary conflicts; inadequate utilization of forest resources in absence of sufficient knowledge, skills, and techniques of forest product harvesting and protection; encroachment and damage of forest areas by influential people in the name of construction projects; neglect of environmental impact assessment (IEE, EIA) obligations in construction of infrastructure such as roads and new settlements (Pathak et al. 2017). To overcome these limitations, management not only of community forestry but also the adoption of various other forestry modalities and systems becomes crucial. Most important is to ensure the full-fledged good governance at all levels including strict observance of complete accountability, transparency, impartiality.

In the context of southeast Asia in general Carrasco et al. state the following observations:

- Lack of accessible ecosystem services (ES) evaluation techniques;
- Limited knowledge of the connections between forests, food security, and human well-being;
- Weak demand and political will for the integration of ES in economic activities and environmental regulation;
- A disconnect between decision-makers and ES evaluation mechanism;
- The lack of discussion platforms where stakeholders can work towards consensus on negotiated land-use management decisions; and
- Prevalence of corruption and power plays in land-use planning processes (Carrasco et al. 2016).

The above-stated observations apply largely also for countries like Nepal as evidenced by many cases including the recent ones related to the most controversial government plans to construct an international airport in the Bara district in the Terai and develop the Far-west Province capital and its infrastructure beside a most fragile Chure hills section of Kailali district by felling many thousands to millions of valuable trees from dense natural forest ecosystems instrumental in the management of local community livelihoods besides many other contributions they have had been making in the maintenance of overall ecosystems around them (Kantipur 2018; Ojha 2018).

Table 3: Forest Area (% of Total Land Area) by Select Asian Countries and the World

Country	Year		**Country**	Year	
	1990	2015		1990	2015
Bhutan	53.7	72.3	Nepal	33.7	25.4
China, PR	16.74	22.19	Philippines	22.0	27.0
India	21.5	23.8	South Korea	66.04	63.44
Indonesia	65.4	50.2	Sri Lanka	36.42	33.01
Japan	68.4	68.5	Thailand	27.41	32.10
Malaysia	68.11	67.55	Vietnam	28.77	47.64
Myanmar	60.0	44.5	***World***	***31.8***	***30.8***

Extracted from: WBG (data.worldbank.org), 2018.

 ISBN: 978-86-87043-85-5

Drawing on and extensive review of socioeconomic assessments of forests and social forestry across many parts of the Asian region in general and Nepal in particular, the following comprehension emerges:

- Despite the growing awareness about the benefits of forests and the concerns (local, national, and international/global) to protect and enrich them, they are degrading, depleting and even being destroyed in many areas.
- In many areas, there are increasing incentives for exploitation of forest resources. Poaching, illegal logging, forest clearing for cultivation, unplanned or inappropriately planned large construction projects are some of the consequences/practices.
- In many parts, acute shortages of fuel-wood, fodder, timber, and other forest products are occurring.
- Forest fire and, to some extent, excessive exploitation, mismanagement, climate change effects and rising pollution are putting negative impacts on some forests, leading in some cases to their complete damage.
- Misuse of forest resources has significant social, economic, and environmental costs that have local and national implications.
- Local inhabitants of farming-dependent areas are forced to out-migrate due to emerging problems.
- Cultural diversity is threatened from depletion and eventual extinction of essential species.
- In settlements where people rely heavily on firewood for cooking and heating, and fodder for livestock rearing, the reduced supply of fuel-wood and fodder have made life harder especially for women and children who are the ones chiefly participating to gather such products. They also have to spend much time and effort in such common chores and loose potential opportunities for productive endeavors such as education and economic enterprises.
- In connection with the above section, there have also been encouraging signs especially of late where plantations for rich vegetation around settlements for various purposes such as beautification, conservation, climatically comfortable and safe conditions, pollution control, and domestic supply of some amounts of fresh fruits, flowers and vegetables have been strongly emphasized and recommended in sustainable integrated human settlement planning schemes (Ojha et al. 2018a, 2018b).
- Overall, ecosystem degradation (deforestation and desertification, biodiversity depletion, soil erosion and landslides, floods, drying of water resources, depleting soil nutrients, watershed degradation, declining farm productivity and production) leading to poverty and deprivation in many rural areas, and hence in urban too (congestion, scarcity, pollution, conflict, chaos).

Under such overall circumstances prevailing worldwide (Table 3 above), especially in economically poor and geologically fragile areas, expanded and invigorated development and management of social forestry could greatly contribute to ameliorating the adverse situation and rendering people's lives substantially comfortable, productive, progressive, prosperous and charming thus eventually leading to a situation that could make the onset of the process of sustainable human development possible. For instance, Kathmandu Metropolitan City in Nepal would be looking merely a concrete jungle of dwelling sans the impressively wide and dense coverage of forests surrounding the numerous temples in the city known also for a long time as the City of Temples.

Pashupatinath, Swayambhunath, Karya Vinayak, Soorya Vinayak, Jala Vinayak, Vajra Yogini, and Maha Lakshmi are some of the most prominent sites with lush green forests surviving and even thriving to some extent till date since ancient times thanks to the spiritual

sentiments and practices among people in the Valley towards these sacred seats and the vegetation around them. Similar social (religious) forests are to be found across many parts of the country from the plains to the high mountains (e.g., Muktinath, 3,710m above the mean sea level). These and many similar and varied social forestry systems do greatly contribute to the overall forest cover, quality and services in the country. A few cases of encroachments of some of such lands have also been reportedly occurring now and then however but to a little extent unlike for other community-managed or national forests and forest resources.

As such, social forestry does have substantially contributed already in the economic, social, and environmental wellbeing of people and places across the world. However, in areas where it is required most imminently it has not flourished sufficiently and is beset with a variety of constraints. Overcoming those limitations is the challenge we face today and exploration and execution of workable and efficient solutions to the problem constitute our imminent need and utmost obligation.

K. Core Requirements for Best Social Forestry Management

Technical dimension

Raising awareness among people (right from childhood) and institutions (right from their establishment) about the characteristics and benefits of forest resources

Imparting education to people (including children and elderly) on growing, protecting (e.g., creating and maintaining fire lines sufficiently and in time), utilizing (e.g., processing, packaging, selling) forest products

Various training packages for people, especially farmers, in such aspects as suitable species selection (e.g., avoiding growing tall and shallow-rooted trees along roads; preferring fast-growing/high-photosynthesis, multipurpose trees for afforestation and reforestation), cultivation, care, commercial use (e.g., craftsmanship and trade)

Large-scale production and distribution of clear and concise social forestry related publications in illustrative, simple style and local languages for various stakeholders in social forestry sector at all levels – local, regional, national; policy-makers, planners, administrators, foresters, farmers, teachers, students, housewives, civil society leaders, activists, environmentalists, conservationists, partner organizations, donors, non-governmental organizations.

Ethical/moral/cultural dimension

Raising and enriching people's awareness and knowledge about the value of forest resources and sense of ethics, spiritual sense/sentiments and moral obligation/responsibility about the conservation of forest resources

Enterprise, entrepreneur, and entrepreneurship dimension

Motivating, mobilizing, orienting potential entrepreneurs for their strengthened and successful entrepreneurship and enterprises based on social forestry resources production and use

Institutional dimension

Creating and operating specialized Social Forestry Research and Development Departments at related agencies (e.g., government ministry) with specifically trained human resource devoted to the development of social forestry

Establishment and effective operation of specialized, strong, supportive and efficient Banks for Social Forestry (BSF) at suitable and sufficient number of locations

Provision for timely, adequate and suitable types and amounts of inputs (seeds, seedlings, fertilizers, irrigation facility, credit, protection measures – disease and pest control)

Observation/study/research on best social forestry practices/techniques/technology (success cases/ stories), and collection, compilation, and dissemination of advanced and appropriate information, technology and skills among large masses of people

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Organizing regular observation trips (study tours) for students, farmers, forest officials to make them learn from successful social forestry sites (seeing is believing; learning by doing)
Formulating and effectively executing flawless periodic/timely monitoring, evaluation, feedback and follow-up activities for social forestry projects
Organizing competitions among social forestry entrepreneurs, enterprises and rewarding the best performers (farms/forests, farmers, foresters, institutions)

Policy and planning dimension
Periodic review and amendment/reform of rules and regulations encouraging, facilitating, guiding the creations, growth and improved management of social forestry (e.g., ensuring fair and full distribution of benefits to community forest user groups)
Proper planning and budgeting and effective implementation focused heavily on promoting social forestry and ensuring the maximum utilization of forestry resources and benefits
Regulating livestock rearing practices (e.g., stall-feeding instead of rampant stray)
Curbing corruption and ensuring the full functioning of good governance (rule of law) at all levels would be most crucial on top of, and driving, all the above.
Emerging, expanding, enriching, and invigorating momentum of consorted honest efforts from all influential sections of the civil society (activists, advisers, authors, scientists/scholars, and all other conscious, capable, caring individuals and institutions, including a capable, fair, fearless, frank, forward-looking media mechanism) would be most imperative in this regard.
Pairing Social Forestry, and Sustainable Development in all developmental interventions – policies, planning, programming, project formulation and execution, monitoring and evaluation, feedback and follow-up.
Integrating local level institutions and initiatives with international and global level organizations and incentives, means and missions targeted for promoting social forestry and sustainable development. For instance, The Global Landscapes Forum - the world's largest science-led platform on sustainable land-use, connected with 3,000 organizations and 25,000 people through gatherings in Warsaw, Lima, London, Paris, Marrakech and Jakarta (Popescu 2018) – should and could carry out massive and most effective measures in this regard in close collaboration with such concerned and capable global agencies as CIFOR, EDI/WB, ICRAF, IDRC, IITA, UNDP, UNESCO, and WRI.

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 ISBN: 978-86-87043-85-5

Annex

Table A.1: Specific Planning Recommendations for Forestry Especially in Nepal's Context (Sub-ecological zone specific)

Zone	Recommendation
High hills	Deciduous trees planting on ridge tops; multi-story cropping on slopes; rearing livestock at the main dwellings and seasonal huts; rotational grazing or shed rearing; fibre-yielding and soil-holding plants such as *Pollinidium angustifolia* and *Agave americana* in the eroded and slipped areas.
Middle hills	Planting fast-growing tree species or plantation crops on bare hillocks; emphasis on fruit cropping and vegetable growing.
Low hills	Planting multipurpose fast-growth tree species or plantation crops around the denuded hillocks; massive-scale hedgerows at the foothills; wasteland tree planting; field crop intensification.

Source: Ojha, E.R. 1999.

Table A.2: Proposed Major Forestry Actions and Expected Prime Results

ACTIONS
Massive afforestation, especially in the hill tops, slopes and all bare, poorly vegetated or wasted lands.
Rehabilitation of abandoned terraces through orchard terracing and application of other technologies such as alley farming, multi-story cropping and the sloping agricultural land technology (SALT).
Improved preparation and use of farmyard manure and compost to enrich the terraces under field crop cultivation.
RESULTS
Job creation; utilization of labour and other local resources; improved soil, land and terraces; balanced or stabilized ecology; increased productivity and income; enriched human resource.
Improved Living Conditions

Source: Ojha, E.R. 1999.

SDConference Proceedings 2022 ISBN: 978-86-87043-85-5

The Correlation Between Climate Change and Women in Developing Areas

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ABSTRACT:

The climate and the environment heavily influence the way humans live, from their sources of food to sources of income. However, with climate change, developing countries are expected to experience the most adverse effects. The vulnerability arises from the countries' reliance on natural resources and agricultural sectors, as agrarian productivity plays an essential role in improving employment and food security. Yet, climate change lessens the guarantee of rainfall during cropping seasons, decreasing the quality and quantity of agricultural resources.

In developing countries, women are expected to experience the forefront of climate change, as agricultural industries and poverty rates are dominated by women. Climate change has, and will continue to, risk women's physical beings and deplete their sources of food and income.

This research will be composed of a literature review and a case study. The literature review uses recent scholarly articles and analyzes the following in developing areas: (1) patriarchy's effect on women and gender inequality; (2) women's positions in society; (3) impacts of climate change on women in terms of (a) health, (b) mortality rate, (c) economic conditions, and (d) violence; and (4) governmental actions taken to mitigate these issues. The case study will review initiatives taken by three non-governmental organizations: Women Deliver, GenderCC, and Women Environmental Programme. An in-depth discussion of the literature review and case study will then be conducted, comparing the strengths and limitations of the organizations' methods and providing recommendations for policymakers. The findings of this research will urge activists and policymakers to create change.

KEYWORDS:
Climate change, sustainability, women, developing areas, patriarchy, women's rights, sustainable development

 ISBN: 978-86-87043-85-5

1 INTRODUCTION

Since the late 19th century, changes in human activity and an increase in atmospheric carbon dioxide have amplified the earth's natural greenhouse effect, thus resulting in a 1.1°C rise in global temperature. Climate change is increasing the severity and frequency of environmental disasters, changing the patterns of seasonal cyclones, season diversity, and quantity of rainfall (Rahman, 2013). Out of all regions of the globe, however, developing countries are expected to experience the effects of climate change most adversely (Arora-Jonnson, 2011). The vulnerability predominately arises from these countries' reliance on the agricultural sector, as agrarian productivity plays an essential role in reducing poverty and improving food security (USDA ERS, 2011). For example, areas such as Nigeria rely on the sector to provide for 42% of its GDP and employ 70% of the active population (Onwutuebe, 2019). Yet, climate change starkly reduces the guarantee of predicted rainfall and sunshine during cropping seasons, reducing the quality and quantity of agricultural resources (Onwutuebe, 2019). As a result, poorer populations with the least amount of resources and a heavy reliance on the weather will be the most disproportionately affected by climate change (Sheu, 2021).

Of those in developing countries, women are expected to experience the forefront of climate change. Currently, there are 1.3 billion poor people in such areas, and 70% of this population consists of women (Arora-Jonnson, 2011). Women's poverty rates are expected to increase since much of the agricultural industry is dominated by women. The root of this issue, however, stems not from climate change but the patriarchy in developing nations. The gender inequality created by the system has suppressed women into the agricultural industry and vulnerable situations, making them disadvantaged in the face of climate change's effects.

In consideration of gender inequality, women's conditions, and the impacts of climate change in developing areas, the purpose of this research is to provide an overview of climate change's disproportionate impacts on women in developing nations and the system that exacerbates the issue.

2 LITERATURE REVIEW

Much of society— especially developing areas— is currently patriarchal, where men exercise the most power and influence in politics, business, women's rights, and other areas of life (Arora-Jonnson, 2011). Transmitted and sustained through cultural and religious fundamentalism, patriarchy reinforces male supremacy and fails to recognize the equality between men and women; instead, it creates and furthers the gender inequality between the two. This often forces women to be submissive to the opposing gender, continuing to limit women's potential while providing higher levels of prestige to men (Onwutuebe, 2019).

In developing countries, women lack community and governmental support (Glazebrook, 2011; Akinsemolou, 2020). In some cases, they eat the last and the least among their family members, and their needs are taken into little consideration in household and political settings (Arora-Jonnson, 2011). Their education is also disregarded in society and made more challenging to achieve to the extent that in Ghana, only 19% of women have completed their formal education, and 42% are literate; comparatively, 37% of Ghanan men have completed their formal education, and 66% are literate (Glazebrook, 2011). These social constraints limit women's mobility and keep them in vulnerable positions where they often lack the power to make autonomous decisions in their families and communities (Rahman, 2013; Akinsemolou, 2020).

Women currently comprise "one-third of the world's formal sector and do four-fifths of all informal work, but receive only ten percent of the world's income and own less than one percent of the world's property" (Glazebrook, 2011, p. 764). In fact, 70% of the 1.3

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billion living in poverty are women, and the agricultural industry is dominated by women. Poverty has the potential to cause environmental degradation, as poor people over-exploit already strained resources. This, in turn, worsens poverty levels as people are unable to find resources to meet their daily needs, which leaves many women even more economically, socially, and physically vulnerable (Glazebrook, 2011).

In parts of Africa, women are burdened with domestic tasks for their families. They are responsible for 80% of food production, and 70% of the world's farmers are women who produce 60-80% of the world's food crops (Glazebrook, 2011). Girls and women are also typically responsible for preparing food, fetching water, collecting firewood, and disposing of waste to help out their households (Rahman, 2013). While women's roles generally remain static, men have higher levels of flexibility for vocational mobility or change, often migrating to different areas and leaving their families behind (Onwutuebe, 2019). These conditions have not been created naturally but have rather been achieved through patriarchy's systematic use of coercion and threat (Wonders, 2018).

Climate change itself does not directly disproportionately affect women, but "the socially constructed system has created a situation where climate change will play a key role in instigating their vulnerabilities" (Rahman, 2013, p. 75). Women performing in agricultural industries will be especially affected due to environmental changes and increased responsibilities (Goh, 2012), and the gender-based and culturally assigned roles will provide women with less bargaining power within their livelihoods, putting them at the forefront of climate change impacts (Rahman, 2013).

2.1 Health Effects

Climate change influences "the socio-environmental determinants of health, including safe drinking water, proper shelter, adequate food supply, and clean air" (Akinsemolou, 2020, p. 5). In many developing areas, women are frequently socially expected to collect water for their families. When some natural disasters such as droughts occur, the water supply is sharply reduced— many developing countries already suffer from a critical water shortage, and climate change will worsen the issue (Onwutuebe, 2019). To alleviate the shortage and acquire water, women and girls are forced to travel long distances, placing them in dangerous conditions and compromising the quality of the water they collect. As a result, women carry the highest risk of getting in contact with polluted water and falling sick— many fall ill to cholera, malaria, typhoid, or jaundice during and after disasters (Rahman, 2013).

Women are socially expected to eat less than their male counterparts in their households, and women of all ages have been shown to be more calorie-deficient than men. In developing areas such as Bangladesh, 70% of women suffer from nutritional deficiency and 30% suffer from calorie deficiency (Rahman, 2013). With the food insecurity that climate change is expected to bring, such percentages will inevitably increase (Onwutuebe, 2019).

The effects of climate change especially adversely impact pregnant women. During pregnancy, women require higher levels of nutrition and food, and low nutrition is known to cause delivery problems and an infant's low birth weight. Natural disasters and extreme temperatures risk the food and water supply, increasing the likelihood of getting into contact with contaminated food and water (Akinsemolu, 2020). These conditions can expose pregnant women to anemia, risking adverse birth outcomes such as infant mortality or preterm birth (Akinsemolu, 2020). During an in-depth experiment on the correlation between extreme heat and pregnancy, it was discovered that pregnant women have a compromised ability to thermoregulate, meaning that they are susceptible to increasing temperatures

(Kuehn, 2017). As a result, extreme heat can cause preterm birth, low birth weight, and increasing weight of stillbirth (Keuhn, 2017).

Women's health is especially jeopardized due to the poor healthcare system in developing areas. After natural disasters, communities usually prioritize the state of their physical surroundings instead of the physical and hygienic needs of women (Rahman, 2013). Especially in a male-dominated society, the system and its policies are inept to accommodate women's needs, especially with the social taboos regarding menstruation, contraceptives, and birth control pills. These all further the chances of contracting illnesses, including perinea rashes, urinary tract infections, and sexually transmitted diseases (Desai, 2021).

2.2 Mortality Rate

Women are fourteen times more likely to die during natural disasters than men, with more women dying in areas where they were more socioeconomically disadvantaged (Arora-Jonnson, 2011). The high mortality rate stems from diseases and women's limited access to information such as early warning systems— in South Africa, women typically use extension officers as mediums of dissemination for seasonal forecasts and agricultural research, whereas men use radios which can immediately communicate unpredicted events (Goh, 2012). These officers, however, cannot manually inform the population of emergencies, which leaves women uninformed and unequipped to handle such situations. Developing areas also face weak housing infrastructure and feeble health infrastructures that do not have the capacity to respond adequately to natural disasters (Rahman, 2013; Akinsemolou, 2020).

The social constraints and lack of mobility also augment the likelihood of exposing women to situations that can be fatal. In some patriarchal societies, women are forbidden from relocating without permission from a male relative, even amid climate-related emergencies (Akinsemolou, 2020).

2.3 Economic Conditions

Climate change will continue to change historical weather patterns and produce unexpected droughts, rain seasons, and natural disasters. These will contribute to the hindrance in cultivating and harvesting crops. Conventional times of cropping seasons will be altered, and the quality and quantity of agricultural resources will inevitably be reduced (Onwutuebe, 2019, Glazebrook, 2011). The resource depletion translates to food insecurity and drops in crop yields, which decreases the amount of revenue produced within the agricultural sector and women's potential for optimal agricultural productivity (Onwutuebe, 2019).

It's crucial to mention that compared to men, women take more time to compensate for economic losses caused by natural disasters (Rahman, 2013). Many women in developing areas depend on their immediate surroundings and their home for their economic activities. Climate change, however, deteriorates household and working conditions, and many girls in these areas sacrifice their schooling to fulfill their increased domestic duties after environmental disasters— this exacerbates the already low average literacy and education levels (Rahman, 2013). The lack of schooling translates to poorer and less access to developing entrepreneurial skills and ability over financial resources, ultimately stunting women's potential for employment elsewhere. The disadvantage in their skillset, in conjunction with women's lack of property rights, worsens women's vulnerable situations and makes it difficult for them to financially recover after disasters (Sheu, 2021).

Women's decreased economic position is aggravated by the projection that climate change will create price instability with an approximate 30% to 50% increase in prices overall (Sheu, 2021). For poorer households, which mainly consist of women, inflation will worsen their situation and push them further into poverty (Sheu, 2021).

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2.4 Violence

In socially and culturally diverse regions, disasters have been shown to cause an elevation in domestic and public sexual violence against women and girls. In fact, 71.6% of women were subject to more violence during disasters in Bangladesh (Reggers, 2019)— this is caused due to a crisis in family and society, as well as the sudden breakdown of family and community structures arising from forced displacement. (Desai, 2021). After environmental disasters, many families are moved into refugee camps or homeless shelters, which reduces the amount of privacy that women have while they sleep, wash, or dress. These conditions frequently expose women and girls to various forms of sexual violence ranging from rape to sex trafficking (Rahman, 2013).

According to the UN Environmental Programme, trafficking during disasters tend to rise by 20-30%, especially among those in poverty. Cheap labor is typically demanded after weathered events, which creates the conditions of being exploited for human or sex trafficking. The financial desperation creates "an opportunity for a 'supply' of people willing to take on work outside their comfort zone and 'demand' from nefarious individuals to take advantage of those vulnerable people in offering opportunities that may eventually prove to be fraudulent" (Sheu, 2021, p. 325). For instance, after extreme weather events, families from South and Southeast Asia, Central America, and East Africa send children and younger adults to find labor opportunities to support their families' economic situations (Sheu, 2021). Young girls, however, are more likely than boys to be sold by poor families to traffickers during monetary hardships, and women are more likely to be promised employment opportunities that later turn out to be trafficking conditions (Sheu, 2021).

The lack of societal rights for women increases their risk of being victims of sexual violence, yet there are currently no international legal instruments directly dealing with sexual violence against women during and after natural disasters (Sheu, 2021). The ineffective government action prolongs the issue, which will only compound with worsening climate change.

2.5 Governmental Action and Gender Inequality

Most climate change policies revolve around men and lack recognition of women's needs (Wonders, 2018). Recently, the government has been developing and is beginning to recognize the effect that climate change will have on women (Arora-Jonnson, 2011). For instance, the National Policy on Climate Change for Namibia and Mauritius National Climate Change Adaptation Policy Framework both acknowledge that climate change disproportionately affects vulnerable women and the rural poor (Nhamo, 2014). The South African National Climate Change Response White Paper delves further and states that women are particularly vulnerable due to their traditional domestic roles (Nhamo, 2014).

Although the issue has been noticed, proper action has not been taken on a governmental level. Ghana's Poverty Reduction Strategy clarifies that the amount of female population in the agricultural industry has been recognized, but there is too little known about women's situations to develop useful policies (Glazebrook, 2011); Glazebrook suggests that this lack of knowledge originates from women's limited decision-making capacities. On the other hand, Akinseolu's report does not claim that the government is making any effort to reduce the effects of climate change on women. As one example where women are excluded from decision-making despite bearing the most consequences of climate change, only 6% of Ilaje, Nigeria women are represented in the community's politics (Akinsemolu, 2020).

Overall, climate change's impacts on women will only worsen in developing areas. Yet, there are currently no international laws to accommodate refugees after natural disasters to ensure women's safety (Wonders, 2018), effective laws to improve a woman's healthcare

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(Rahman, 2013), or laws to prevent gender-based violence during disasters (Sheu, 2021). Women are underrepresented in politics, yet they are the most environmentally conscious and willing to support drastic measures to mitigate the effects of climate change (Arora-Jonnson, 2011). Due to the underrepresentation that they have received, women's social locations and roles give them unique perspectives on environmental issues (Glazebrook, 2011).

Throughout history, gender inequality created by patriarchy has led to a system where women have little control over resources, production, and management compared to males, thus making them more marginalized and excluded in the fact of natural disasters (Wonders, 2018). If the cycle continues, the inaction and the effects of climate change will lower women's status and increase their dependence on men, furthering gender inequality and intensifying climate change's impacts on women (Onwutuebe, 2021). In areas where women and men have comparable statuses, natural disasters have been shown to affect the two genders almost equally (Goh, 2012), indicating that by adapting to women's needs and reducing the gender gap, society will be able to curb the adverse impacts of climate change.

3 FRAMEWORK

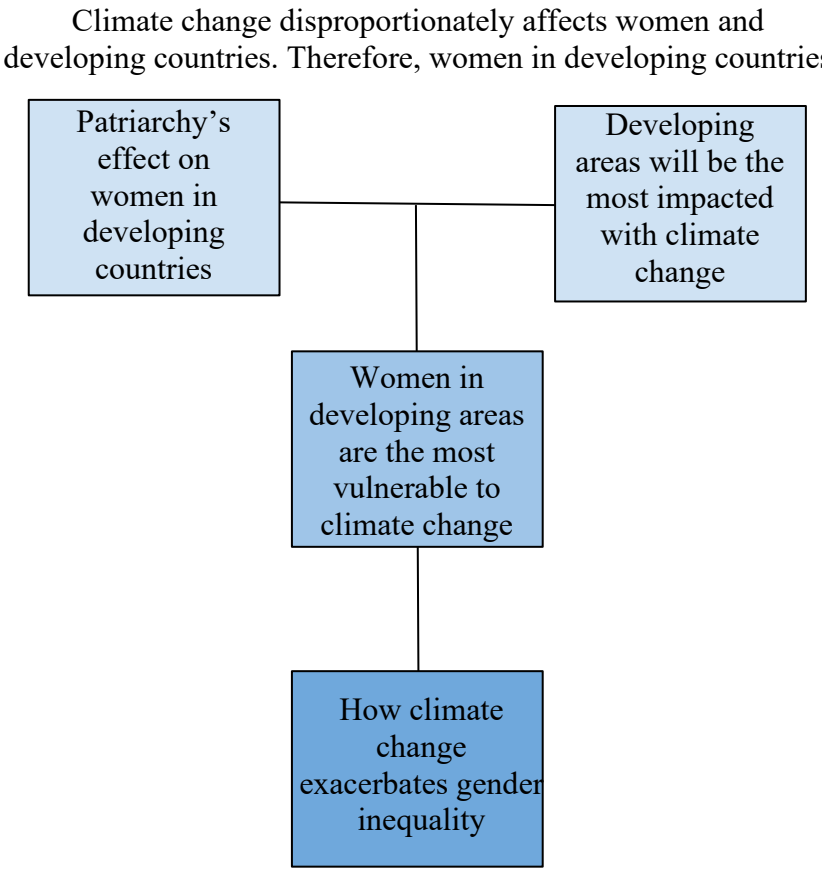

Figure 1

Patriarchy is the societal or governmental system in which men hold the most influence. This belief inherently excludes women and their potential, creating a power and equality imbalance between men and women. As a result, limited women's rights and high levels of male dominance within regions are directly correlated. In 2009, the OECD created the Social Institutions and Gender Index (SIGI), a measure to track gender equality across 102 developing countries in the world. The results revealed that all developing countries

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experienced a certain degree of gender inequality; the majority of the countries in Africa and the Middle East reported high or medium-high levels of inequality (OECD, 2009).

According to Onwutuebe (2019), "patriarchal beliefs are in most cases transmitted and sustained through diverse forms of cultural and religious fundamentalism, which rigidly define what is acceptable and what is offensive to a society in relation to gender beliefs and roles" (p. 2). With this, long-held traditions and religions have created and continued gender inequality to the extent that women receive little representation in decision-making policies (Nhamo, 2014). This prolonged issue has had profound consequences on women's livelihoods in developing areas. Women are often designated as the caretakers of their households and are responsible for gathering food, water, and fuel (Onwutuebe, 2019; Goh 2012). To fulfill their domestic duties, they are typically expected to sacrifice their portions of food and their education; as a result, women typically have lower education levels compared to men (Wonders, 2018). The political system currently limits women's property rights and mobility, with such freedoms typically being reserved for male figures in the family (Glazebrook, 2011; Wonders, 2018; Reggers, 2019). Inequality and cultural expectations have resulted in the agricultural and informal sectors in developing areas being largely composed of women. All these factors have contributed to women's poverty levels—70% of the 1.3 billion poor people in developing areas are women, with poverty rates deepening as the subject continues to be disregarded (Arora-Jonnson, 2011).

Most developing countries heavily rely on the agricultural industry for income and food, yet climate change is expected to bring environmental disruptions that will hinder the growth of crops (Onwutuebe, 2019). For example, floods or droughts will be made more frequent as climate change worsens, yet these disasters could lessen, if not destroy, the agriculture in these regions. In addition, the lack of resources and the poor infrastructure in developing countries will make it difficult to survive and recover from extreme weather events (Sheu, 2021). These will set the process of poverty alleviation back (Reggers, 2021), making developing areas exceptionally susceptible to climate change.

Climate change's adverse impacts on developing countries, women's poverty rates, and women's rights in these areas suggest that women in developing countries will be the most disproportionately affected by climate change. Women's existing high poverty rates and their lack of mobility indicate that they will experience high mortality rates during disasters, as poor areas typically cannot access advanced information systems or well-constructed houses (Rahman, 2013; Arora-Jonnson, 2011). Shifts in agriculture will result in food and water scarcity, in addition to the deterioration of women's economic and social standings. After extreme climate events, women will have heightened domestic responsibilities and will be forced to rely on their depleted surrounding resources to survive (Rahman, 2013; Wonders, 2019). In addition to the health and economic risks that women face, the lack of medical care in developing countries will aggravate their insecurity (Akinsemolu, 2020). Limited access to social networks, transportation, information, skills, economic resources, employment, and decision-making power will make it especially difficult for women to recover from these disasters (Rahman, 2013).

Women's societal standings will likely worsen after climate-related disasters. Many girls are projected to sacrifice their schooling to care for their families, thereby restricting their abilities to seek out better future opportunities. Economic insecurity will spike, increase a woman's already high dependence on men (Wonders, 2018), and exacerbate the social and political dominance that men have over women. Currently, climate change policies generally revolve around men due to the lack of representation of women in politics (Akinsemolu), but climate change's impacts will ultimately continue to strengthen the long-held social standings around patriarchy (Desai, 2021).

 ISBN: 978-86-87043-85-5

4 CASE STUDY

In recent years, several efforts have been taken to mitigate the adverse effects of climate change on women. A few notable actions have been made by non-governmental organizations: Women Deliver, GenderCC, and Women Environmental Programme (WEP). I will discuss each of them in detail in this section to learn from their work in addressing gender equality in the face of climate change.

Women Deliver, founded in 2009, has been working to achieve gender equality, as well as sexual and reproductive health and rights. With women's health and unequal gender rights being exacerbated by climate change, the organization has been taking global initiatives to increase women's accessibility to financial and other resources needed to adapt to environmental changes. GenderCC, on the other hand, is an organization specifically dedicated to achieving gender and climate justice. Since 2008, it has worked in multiple fields related to climate change, from agriculture to waste, with many of its projects hosted in developing Middle-Eastern and African countries; in 2010, an independent branch was created in South Africa, an area critically impacted by climate events. Women Environmental Programme, the oldest of the three NGOs, was founded in 1997 in Nigeria. It aims to tackle gender injustices related to women's environmental, economic, and social rights, impacting over 20 million people since its creation. Much of WEP's initiatives are focused around Nigeria and other South African countries, as these areas have been proven to be severely damaged by climate events. The three organizations have made significant progress in promoting change to combat patriarchal regulations, assisting women's economic conditions in developing areas, and supervising women's health after natural disasters.

In consideration of climate change's financial and physical impacts on women, in addition to the lack of governmental action taken, I organize this section by dividing the organizations' efforts into three categories: policy change, economic development, and health advocacy. The first section will discuss general initiatives that address gender inequality and women in climate change regulations, the second will include actions specifically taken to assist women's monetary hardships, and the last section will focus solely on efforts that combat poor healthcare infrastructures and protect women's physical bodies. Instead of speaking of each organization separately— which can blur the relevance between the issue and the NGOs' projects— the sub-sections distinctly highlight how their efforts align in terms of alleviating the existing gender and climate injustice.

4.1 Policy Change

Currently, many developing nations' politics revolve around patriarchy, leaving women with little representation in policy-making, including those related to climate change alleviation. Yet, with women being disproportionately impacted in economical, physical, and social aspects, the lack of women and their needs in climate change regulations will have large implications in the future— furthering the gap between men and women and increasing the severity of the impacts women experience with climate change. Therefore, these three organizations drive gender and climate policy change through their projects.

Women Deliver currently has a strategic framework from 2021 to 2025 that will focus on championing the interlinkages between climate change, gender equality, and sexual and reproductive health and rights (SRHR) through high-impact global advocacy work around climate, health, and SRHR— they will influence decision-makers, drive collectivist feminist actions, and amplify the evidence base against gender inequality and climate change. Women Deliver has conducted annual reports on the matter, compounding information from previous years, and will continue to collect evidence. To further build evidence, the organization plans to engage with diverse climate action advocates and shift narrative through articles, storytelling, and leadership in online and offline platforms. As it did in prior years,

 ISBN: 978-86-87043-85-5

the organization plans to present the data to raise awareness and influence policymakers in the United Nations Framework Convention on Climate Change (UNFCC) Conference of the Parties (COP), the United Nations High-level Political Forum (HLPF), the United Nations General Assembly (UNGA), the United Nations High-Level Meeting on Universal Health Coverage, the World Health Assembly (WHA), and the Commission on the Status of Women (CSW). This will "build allies, raise awareness of the interlinkages between climate action and SRHR, influence norm-setting, and ensure that SRHR is positioned as integral to climate change adaptation and resilience measures through advocacy with global health and climate leaders" (Women Deliver). The results of this project have yet to be seen or updated, as it is still ongoing.

It has previously been revealed that policymakers have been unable to effectively include women in climate policies due to the lack of knowledge of women's experiences. GenderCC is currently directly involved in international climate negotiations such as the UNFCC, helping women and gender experts work on policy, research, and practical implementation at international and local levels. Notably, on November 24, 2011, GenderCC South Africa organized a conference where over 50 women from South Africa and other world regions gathered to brainstorm their climate change-related experiences and challenges. The participants then discussed key problems and solutions before presenting the statement at COP17, a United Nations conference with the supreme decision-making body responsible for addressing and regulating climate change. Women in developing areas severely lack property rights, access to reliable information, and education. To combat these matters, GenderCC was able to raise issues and demands for women's access to funding, government transparency, access to information, education and capacity building, access to productive land and other resources, and participation and inclusion in policies. This method allowed women to raise awareness of their personal experiences, which directly gives policymakers insight into women's needs. However, these were raised during an international conference, and local setbacks may be challenging to combat. COP meetings generally focus on widespread change and would generally disregard problems faced within narrow scopes.

In addition, starting in 2010, GenderCC and other South African gender organizations have been involved in altering the National Climate Change Response Policy, South Africa's official climate change relief policy. The initial policy was a comprehensive plan in Africa to confront adaptation and mitigation in the short, medium, and long term by addressing the following areas: carbon pricing, water, agriculture, commercial forestry, health, biodiversity and ecosystems, human settlements, and disaster risk reduction and management. However, the policy did not account for women who did not have access to computers and the internet, largely excluding them from the decision-making process— the limited knowledge of women in poverty has made it historically difficult to cater to their needs, worsening their situations over time. In GenderCC's "Gender Review of the National Climate Change Response Green Paper 2010," the paper highlighted the criticisms regarding the policy: the participation of women has to be expressed in the policy principles, and the paper should not only recognize the social and economic consequences but also the gender sensitivity of the issue. After information-sharing sessions, strategy meetings, and conferences where the criticisms were presented, the recently revised response policy now incorporates gender into the paper. Nonetheless, it is important to note that merely recognizing the problem within the policy is not effective enough— the government has yet to implement strategic measures to assist women.

GenderCC has also launched projects in developing areas such as Bangladesh that are already experiencing the impacts of climate change. In Bangladesh, rising sea levels have caused storms and floods that have destroyed livelihoods in fishing communities, and unpredictable rain patterns have made cultivating lands unprofitable and poor. Although the

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government launched a climate change strategy and an action plan and has begun to provide financial resources for adaptation, these policies have lacked gender sensitivity despite women facing the brunt of the adverse effects. This, combined with the weak position of the nation's Ministry of Women and Children Affairs, has made it difficult to address gender issues with the Ministry of Environment and Forest which is responsible for climate change mitigation. GenderCC, by partnering with the Center for Global Change (CGC), organized a conference in Bangladesh in April 2010, which held participants from the government, donors, NGOs, and civil societies. From the meeting, CGC initiated the topic of gender sensitivity, with participants urging policymakers to take action on gender-sensitive relief packages, gender-disaggregated data in areas of climate change, and alternative income-generating activities for women.

The Women Environmental Programme, similarly to GenderCC, has participated in COPs, with the organization making a significant effort during COP21 in 2015. Two months before the conference, WEP collaborated with Nigeria's Federal Ministry of Women Affairs and Social Development (FMWASD) to create an agenda-setting forum on sustainable development goals (SDGs) that consolidated and articulated the position of Nigerian women on climate change. The forum held first-hand stories of women and their negative experiences with climate change, especially with Nigerian women's lack of social rights and heavy reliance on the agricultural industry. Using the information, during COP21, WEP presented the "Nigerian Perspective on Water, Gender, and Climate Change" and demanded gender equality and human rights in all climate action policies. However, since this was presented during an international conference, it was difficult to see results, as this problem applied on a regional scale.

WEP and four other organizations have also been involved in The Women2030 Project, a 5-year strategic agreement created to build the capacities of women's and gender-focused civil society organizations on planning, monitoring, and implementing sustainable development goals to ensure more gender-responsive actions with the participation of women and women's organizations. The project is currently being implemented in 52 countries across the globe, with many being developing countries in Africa, Easter Europe, Latin America, and Asia. Since 2016, the program reached out to more than 189 women's rights and feminist partner organizations, engaging them in climate-related policy processes. Reportedly, from the Women2030 Project, "754 feminists used their 'civil society seats' at policy tables, engaging with their country's high-level representatives;" "123 sub-grants are to document local women's challenges and priorities, and prepare good practices to present to policymakers;" "27 community-based assessments and 23 Women2030 shadow reports have been included in the UN policy process on SDGs to push for policy change at local levels;" and "17 countries have improved-gender responsive national plans, policies, and institutionalizations" (WEP).

In summary, the three NGOs all advocate for climate and gender justice by urging policymakers to create change. With the information on women being limited in climate change policies, these organizations serve as mediums that raise awareness of the issues faced by women. Women Deliver appears to have the most widespread approach out of the three organizations, as the 2021-2025 Strategic Framework focuses on gathering information on a global scale and seeking justice through international conferences. On the other hand, WEP and GenderCC appear to target gender issues at both international and regional levels. GenderCC works in various areas of the globe, with many of its projects previously being centered around South Africa, Bangladesh, and other areas disproportionately impacted by climate change. Most of their policy change methods also focus on raising awareness during meetings, but presenting the matters in both local and international settings may enhance the effectiveness of achieving their goal. WEP seeks improved conditions in Nigeria— through

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their COP meetings— as well as globally. Unlike other organizations, WEP's policy change methods do not only include participating in climate conferences but also inspiring women to become leaders within their communities.

4.2 Economics

It has previously been discussed that climate change will likely heighten women's economic instabilities in developing areas. The combination of environmental destruction, increased domestic duties, inflated prices, and lack of gender equality all deepen women into poverty levels.

To lessen the issue, Women Deliver has been focusing on addressing girls' and women's disproportionate burden of unpaid care work and gender inequality in the health and care workforce. As a part of its 2021-2025 Strategic Framework, the organization aims to confront the impact of climate change on girls' and women's access to work and the burden at home. The organization has participated in events such as the United Nation's 66th Commission of the Status of Women (CSW66), which discussed the crucial role of social, labor, environmental, and economic policies in ensuring gender equality. Women Deliver has also conducted an international survey that revealed that the "global public believes that the unequal distribution of unpaid care work and domestic responsibilities between men and women is one of the greatest barriers to gender equality around the world" (Women Deliver). The evidence was then presented at the UN Women's Generation Equality Forum in 2021, which discussed gender investments and policies. The Forum ultimately launched a 5-year action journey to achieve gender equality, with economic justice and rights being one of the goals.

WEP has been making direct efforts to assist women in poverty situations after climate-related disasters. With a program called the Rural Women Energy Security (RUWES), the initiative aims to lower market entry barriers to the clean energy market. RUWES's mission is to specifically empower women economically by making them the marketers and distributors of clean energy products. Since women are typically responsible for gathering wood or other fuels in developing areas, the program has introduced a substitute item: briquettes. Though briquettes can burn effectively like wood, they are densely compressed with cheap biomass wastes and burn slowly. WEP has installed a machine in Adikpo, Nigeria to produce briquettes, providing women with inexpensive cooking options while remaining sustainable.

Climate disasters are projected to cause land degradation, limiting the number of resources available in developing areas and deepening women into poverty levels. As a result, WEP has launched the Great Green Wall Project to tackle the social, economic, and environmental impacts of land degradation in northern Nigeria. The organization is building women's capacities to efficiently use energy to conserve surrounding resources by teaching women to construct energy-efficient cook stoves from easily accessible materials. Given the critical damage that climate change will inflict on the agricultural industry and the economy, WEP is also teaching women about alternative sources of income, reducing their over-dependence on farming and empowering them financially.

Women in developing nations typically have lower educational and financial exposure, which contributes to their lower economic status compared to men. As a part of WEP's "Connecting Women and Youth in Violent Extremist Prone Areas through Empowerment and Skills Acquisition in Benue State" program launched in 2016, young Nigerian women and men were trained on their vocational skills, also providing them with start-up grants to enable them to set up businesses in various areas. According to WEP, 134 women and 134 men were able to be trained, which has "improved the income and livelihood opportunities of these young women and young men."

In summary, Women Deliver and WEP make great efforts in improving women's economic status through different methods. Women Deliver focuses on gathering and sharing information through surveys and displaying the unequal distribution of work between the two genders during conferences. WEP takes a more direct approach by working with women in developing areas. Given that the lack of education is one of the factors that causes economic inequality, WEP educates women in small communities on financial skills and sustainability. These two approaches are both important with one educating a global audience and another focusing on impacting at a local level. Both are necessary to create change, and the more these organizations can work in tandem, the more they can enhance the effect of the other.

4.3 Health

Climate change is expected to have detrimental effects on women's physical beings. Women in developing areas are more likely to die or contract diseases during disasters due to contaminated water, poor housing and health infrastructures, and food insecurity. In addition, women's likelihood of being victims of sexual assaults spikes after disasters, since many women are placed into gender-neutral refugee homes that lack privacy.

Women Deliver has been dedicating much of its climate action initiatives to combat the effects of gender-based violence. In 2019, the organization helped draft the Gender Equality Advisory Council's Biarritz Partnership on Gender Equality, which was made up of progressive gender laws and policy recommendations. These sought the inclusion of promoting women's health through access to safe abortion, contraception, and comprehensive sexual education. This opposes the social taboos around the female anatomy, which have not prioritized women's sexual and reproductive health throughout the years. Eleven nations have currently taken up these recommendations in their national policies. However, it is crucial to note that none of these countries are developing nations, which may limit the amount of influence that the adaptation will have.

In addition, from the Generation Equality Forum in 2021, Women Deliver served as one of the catalyzing founders of the SRHR and Climate Justice Coalition, a global network of over 25 civil society organizations committed to achieving gender equality and sexual and reproductive health and rights in the context of climate change. To achieve its purpose, the coalition aims to document "the impact of climate change in the access to SRHR, use their network to identify communities or groups where SRHR has been especially adversely impacted by the climate crisis and seek to provide platforms," (Women Deliver) and advocate for sexual and reproductive health and equitable access to health care.

WEP has also begun the Girls and Women Initiative in Nigeria (G-WIN) project to empower hard-to-reach Nigerian women and girls. During climate disasters, many women are forced to travel long distances to acquire water but often fall ill due to contamination. To specifically target this issue, WEP and Nigeria's Federal Ministry of Water Resources have made it their vision to make women leaders in water management. They are currently striving to provide water and sanitation facilities in public places, overall improving the hygienic conditions of rural populations and preventing them from contracting diseases. This would also help pregnant women, as pregnancy complications often arise from the consumption of contaminated water.

Overall, Women Deliver and WEP target various areas regarding women's physical conditions and utilize different methods to address the issues. Women Deliver strives to assist women in the aftermath of sexual and domestic violence by creating recommendations for in-depth sex education, safe abortions, and enhanced healthcare systems that accommodate women. In contrast, WEP aims to prevent scenarios that allow women to become ill since the organization is aiming to provide clean, local sources of water. Similar to the necessity of the

two organizations' methods in managing women's economic hardships, both approaches are crucial in minimizing the physical impacts that women will experience.

5 DISCUSSION

The three organizations mentioned during the case study function within various ranges of focus. Women Deliver, as an organization focused on women's sexual and reproductive health and rights, focuses mostly on women's health rather than climate and gender justice. However, with climate change rapidly becoming more urgent, its recent 2021-2025 Strategic Framework regards women's physical beings along with their domestic burdens. Its method of influence focuses on collecting data and presenting it to policymakers, in hopes to create a global change. On the other hand, the Women Environmental Programme and GenderCC are organizations whose missions specifically incorporate "women" and "climate change." Their initiatives explore a wide range of factors that worsen gender issues amidst climate change. WEP works on transitioning to sustainable energies, preventing land degradation, and stabilizing women's economic conditions. In addition to advocating during conferences, the organization has taken efforts to directly serve Nigerian women, providing education on sustainability and vocational and entrepreneurial skills. GenderCC's involvements mostly focus on directly tackling women in climate relief policies and the lack of women's rights in developing nations, which have been created by the patriarchy. Similar to Women Deliver and unlike WEP, GenderCC drives change through a collective process—by influencing policymakers— as opposed to launching projects that directly assist local areas.

The NGOs also appear to operate within various areas of the globe. WEP is an NGO founded in Nigeria, a developing country at the forefront of climate change and patriarchy's adverse impacts. This gives the organization a keen insight into the political, social, and economic conditions of the country, thus allowing it to launch several projects that directly assist local Nigerian communities. Since WEP is primarily focused on improving the climate and gender conditions in Nigeria, this can limit the extent of their influence, but it allows the organization to make significant regional changes. Recently, however, the organization has begun to assist other nations through its Women2030 Project, which makes the NGO operational on an international and regional scale. Women Deliver and GenderCC were founded in the United States and Germany, respectively, which are first-world nations that experience climate change less severely than developing ones. Women Deliver currently does not have offices in developing countries, potentially explaining why the NGO's initiatives typically regard gender and climate justice on an international level, as they lack the knowledge of local developing areas. This may also be why GenderCC developed a branch in South Africa. The subsidiary allows the organization to gather information on the area, cater its regional projects accordingly, and effectively target the most impacted areas.

All of the NGOs adopt a similar strategy in creating change: gathering data and presenting it during government conferences to alter climate policies. Though these efforts are not guaranteed to succeed, this may be the best method in influencing widespread change, since the adverse effects of climate change on women are rooted in the lack of representation of women in politics. The three organizations researched have all participated in high-level conferences regarding climate change, such as the UNFCC Conference of the Parties, and have had their ideas incorporated within policies. It is evident that the NGOs are well-recognized and influential, yet the degree of influence that arose from their recommendations is unknown. For instance, GenderCC said that it raised awareness of climate and women-related issues during COP17 but fails to mention if benefits arose from their suggestions.

Given that the information about the NGOs was collected directly from the organizations' websites and reports, there is a possibility of bias and questionable credibility.

Although some NGOs claim to have had a part in creating change with other organizations, they do not mention the extent to which their organization assisted. Specifically, WEP's Women2030 Project and "Connecting Women and Youth in Violent Extremist Prone Areas through Empowerment and Skills Acquisition in Benue State" Project report the changes that the projects have made on regional and national scales. Other factors have been involved in the founding of these projects, WEP does not mention its level of involvement, making it difficult to assess the organization's influence and effectiveness. In addition, the NGO does not mention the method used to measure the effects of the programs, which may allow for inflated results.

5.1 Recommendations

5.1.1 Education System

Women's low education and literacy levels in developing areas have contributed to their reliance on the agricultural industry, limited mobility, and lack of decision-making power (Glazebrook, 2011; Wonders 2018). However, the agricultural industry will inevitably be impacted by climate change, which will only increase women's domestic burdens, food insecurity, and poverty levels (Onwutuebe, 2019). Therefore, it is important to economically empower women through proper education and expand their opportunities beyond the farming sector. Developing areas' budgets and women's domestic duties currently make it difficult to establish physical schools, but short, educational programs could be launched in developing towns to teach women of all ages skills regarding literacy and finances. Such teachings would give them the necessary skills to employ in formal sectors that provide more stability in the face of climate change. This enhances the current working generations' living standards and heightens the possibility of future working generations escaping the agricultural sector.

Women could also be taught on using efficient and sustainable materials to meet their daily needs, as over-exploiting limited resources can aggravate poverty levels and worsen environmental degradation (Glazebrook, 2011). WEP's Rural Women Energy Security Project and the Great Green Wall Project have both been effective in allowing rural Nigerian women to achieve their needed tasks while conserving the surrounding resources and the environment. If the government or more NGOs chose to implement similar education systems in developing towns across the world, this would lessen the amount of climate change while simultaneously assisting women.

Improved education could allow many women to escape from a cycle of resource depletion and poverty. Breaking such a cycle and improving their financial levels has large implications for women, including reduced trafficking, increased stability and property holdings, easier compensation from disasters, less reliance on male figures, and potential participation in politics.

5.1.2 Access to Information

In much of South Africa, compared to men who use radios as mediums of information, women typically use extension officers who serve as intermediaries between agricultural research and farmers. These officers assist women with their agricultural productivity and seasonal forecasts, but heeding emergency warnings regarding climate events is difficult; unexpected disasters and the lack of preparation correlate to women's high mortality rates in developing areas (Goh, 2012). Therefore, the government in these countries should improve the mediums of dissemination, especially for urgent events. This can either be achieved by placing town-wide emergency sound systems or providing each household

 ISBN: 978-86-87043-85-5

with radios similar to that of men's, which both allow women to be prepared for unpredicted weather events.

5.1.3 Refugee Homes

After climate disasters, many women and young girls face violence due to their migration to refugee homes and the lack of privacy they face there. However, there are currently no actions taken to alleviate such violence (Wonders, 2018). The government needs to establish regulations that increase security within these places to protect women. Local law enforcement officers should be positioned within these homes to oversee the conditions. The method would discourage troubles from arising and prevent violence, rape, and abduction against women.

5.1.4 Healthcare System

Poor health infrastructure is one of the leading causes of diseases and deaths post-disasters in developing areas. Similar to Women Deliver's initiatives, governments must regard women's health and hygienic needs, especially when there are existing stigmas regarding menstruation and contraceptives (Desai, 2021). The social taboos worsen conditions for women and increase their probability of falling ill or dying, with the problem being aggravated by communities failing to prioritize women's needs (Rahman, 2013). Given these and the high chances of women becoming sexually assaulted after disasters, healthcare systems need to prioritize women and assist with diseases, safe abortion, and contraceptives.

5.1.5 Clean Water Source

In developing nations, after disasters, much of women's health complications arise from water— women must often travel long distances to acquire water but come into contact with a contaminated source (Rahman, 2013). Therefore, WEP's G-WIN Project aims to provide clean water in public areas across scattered places in Nigeria. Inspired by this initiative, governments, and organizations should strive to provide clean water sources or water filters in developing towns. A clean supply within proximity prevents women from being in unsafe situations and consuming contaminated water, reducing the risk of contracting diseases that can result in complications in pregnancies or fatalities.

5.1.6 Local Women in Politics

National and international climate relief policies have not made effective progress in reducing climate change's effects on women. Although several countries have previously recognized that women face the brunt of climate change, they have claimed that there is too little known about their conditions to create or adjust regulations (Glazebrook, 2011); most of the regulations instead revolve around men. Therefore, gender and climate organizations should train local women about procedures in politics before bringing them into regional political settings. This allows them to vocalize the issues that they face from patriarchy and climate change, in addition to suggesting possible solutions to assist the problems; addressing these in national or international settings can prove to be ineffective since local matters cannot be applied to widespread policies. It has previously been discussed that women's marginalized positions have made them more environmentally conscious than men (Arora-Jonnson, 2011), which gives them a unique perspective on mitigating climate change's effects. Incorporating women in local politics would not only be effective in reducing climate change's overall impact on the environment and its people but also allow women to combat societal hindrances and have a more visible space amidst policymakers. The increased representation has the potential to bring more attention to issues disproportionately affecting women.

SDConference Proceedings 2022 ISBN: 978-86-87043-85-5

6 CONCLUSION

This paper concludes that climate change is especially detrimental to women in developing areas and will enlarge the existing gender inequality. The case studies demonstrate that the organizations are pursuing change by providing recommendations for climate and gender policies or directly assisting women in most impacted areas. Governments currently lack women in politics and climate regulations, which prevents women from receiving sufficient assistance. However, it is crucial to note that climate change's correlation to gender is a recently recognized matter that is rooted in centuries of patriarchy and gender inequality. Due to the longevity of the system, it is improbable to completely abolish patriarchy and the stereotypes against women within the near future. With the sources of the problem remaining to some degree, climate and gender initiatives by NGOs and governments— as well as the mentioned recommendations, if adopted— may take considerable years to be noticeably effective. Nonetheless, the urgency of climate change is heightened; if no action is taken, the adverse impacts of climate change and the gap between men and women will only continue to increase.

 ISBN: 978-86-87043-85-5

ACKNOWLEDGEMENTS:
To my parents, thank you for always supporting me throughout my endeavors and believing in my ability and persistence.

FUNDING:
This research received no external funding.

CONFLICT OF INTEREST:
Authors declare no conflict of interest.

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SDConference Proceedings 2022 ISBN: 978-86-87043-85-5

The Fallacy of Water Governance: A Comparative Analysis of Predominant Approaches

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INTL4700, Senior Thesis

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at

Webster University

Fall 2021

 ISBN: 978-86-87043-85-5

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 ISBN: 978-86-87043-85-5

Introduction

When the well is dry, we know the worth of *water*.

(Benjamin Franklin, 1746).

It seems water has always been imbued with a spiritual and existential significance. However, global industrialization introduced political and economic significance to water, creating the water predicament's complex institutional, empirical, and physical reality. Despite technological advances, no sustainable global solution has successfully ascended to water's salvation. The regional water crisis quickly surpassed its borders, turning water into a pre-eminent global risk. Water, more than ever, has become the single detrimental component of sustaining existence as we know it. Although water is inherently scarce, as less than one percent of freshwater resources are tangible for consumption, the catastrophic water crisis is acknowledged to be men's creation, with agriculture being the largest consumer (75 percent), followed by industrial use (20 percent) (Loucks, 2005). However, these sectors are ultimately controlled by selected transnational corporations known as the agribusiness sector.

By the time water was recognized to be endangered, its convolution was proven to be formidable. Diverse management schemes, undefined value, problematic quantification, and ambiguous power relations among diversified groups created an unprecedented entanglement and urgency to resolve. Water entered the global debate, causing much emotional commotion over its conceptualization and value. Two approaches emerged as a pragmatic response to the crisis; the idealist approach that contends water is a Human Right, and the Neoliberal approach which supports the commodification of water. While these two approaches were passionately fought over, directly and indirectly, the crisis' locus was severely overlooked; *power*. Water, all the more so, had become the presentation of power relations dictating the livelihood and freedom of all living beings. Flyvbjerg's comparison of idealism versus realpolitik, in addition to Foucault's assumptions on power, knowledge, and conflict, offers an applicable framework to expose its hidden forces. This paper will explore the capacity of the Human Right to Water (HRW) to overcome the existing power relations across local, national, and international scales and to promote a more efficient water management that could increase waters availability and accessibility.

Water: Categories, Water Footprint and Virtual Water

Categories and Water Footprint.

The complexity of defining, quantifying, and tracing water along interlaced global economic and political streams has resulted in the introduction of water categories aiming to trace water flows and link consumption patterns to its global impact. Water is categorized into three distinct terms: firstly, blue water, which refers to all fresh surface and ground water resources (e.g., lakes, rivers, aquifers). Secondly, green water that stems from rain, soil moisture (e.g.,

 ISBN: 978-86-87043-85-5

precipitation). Thirdly, grey water, that is contaminated water as a result of industrial or domestic processes (Grove, 2011). Whereas green waters value is embedded in its land cost, blue water requires investment in water infrastructure (Hoekstra & Chapagain, 2006). Trading of embedded water, otherwise known as Virtual Water (V.W.), in forms of land, crops, or goods, became a sought-after solution for water import and scarcity, indicating water market flows and their reflective relationships.

The water footprint, being the cumulative total of domestic water use and the net virtual water import, consumed by one individual or by the individuals of one country, was developed by Hoekstra and Hung to measure VW use over entire supply chains, including its consequential pollution (2002). Due to the lack of green water flows, the water footprint is limited to blue water. Nevertheless, Hoekstra et al. (2012) recognize that agriculture consumes 92 percent of the virtual market flows, with Bunge as its major flows' administrator (Sojamo & Larson, 2012). Because a product's virtual content indicates its environmental impact and raises awareness of its required water volumes production, VW clarifies water-exhausting goods and makes water conservation feasible (Hoekstra & Hung, 2002).

Virtual Water

Definition, Emergence, and Uses.

Economically invisible and politically silent.

(Allan, 2003, p. 110).

Introduced by Allan in the early nineties, Virtual Water (VW), otherwise known as 'embedded water' or 'exogenous water', is "the water embodied in a product, not in a real sense, in a virtual sense" (2003, p. 1). VW links water, food, and trade by presenting how the international trade in agricultural commodities influence global food and water security and governance. VW is defined in two ways; as the volume of water that was used in reality to produce a product, which's dependent on its production's conditions, duration and location, and as the amount of water that would have been required to produce it at his final consumption region, further questioning the value of importation vs. production (Hoekstra & Hung, 2002). Since goods transportation is easier than transporting water production, water is almost exclusively virtually rather than physically mobilized, and is nowadays embedded in agricultural and industrial production, as well as forestry and mining (D'Odorico & et al, 2019).

In 1992 the Dublin International Conference on Water and the Environment promoted new reforms of deliberative democracy, environmental governance and multilateralism, transforming the attitude of Water Management (WM) through the promotion of Dublin principles of the Integrated Water Resources Management (IWRM) (Muller, 2015). Dublin's IWRM prioritizes water as a finite resource, promotes stakeholder participation, and most distinctively treats water as an economically valuable good; "water has an economic value in

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all its competing uses and should be recognized as an economic" (Muller, 2015; ICWE, 1992). Following Dublin's reforms, 60 free-trade agreements were facilitated by the World Trade Organization (WTO), in addition to over 2500 bilateral trade and investment treaties signed globally (UNCTAD, 2007). Empowered by the World Water Partnership, the World Bank, and the Global Water Partnership (GWP), water systems were conjoined with profit mechanisms, promoting private sector investment over federal agencies, transforming global trade (Muller, 2015).

As the international food trade skyrocketed, so did the Virtual Water Trade (VWT) and the West's emerging water 'markets' (Colby, 2009). VWT acts as an economic and political instrument to achieve water security within water-scarce and population-rich nations, increasing the global efficient water use by producing water-intensive products in water-abundant regions (Hoekstra A. Y., 2003). The fluctuating nature of VWT demonstrates asymmetry among states; with the U.S., China, India, Australia, Argentina, and Brazil as the largest net exporters and Japan, Italy, Russia, and Sri Lanka as the largest net importer (D'Odorico & et al, 2019; Hoekstra A. Y., 2003). However, trans-national corporations, particularly those based in and empowered by Western governments, such as Budge and Nestlé, emerged as determinate actors of VW flows (Sojamo & et al, 2012). However, their implicit Western hegemony is seemingly challenged with the rise of corporations originating in Asia and the Middle-East (e.g., China and Saudi Arabia) (Sojamo & et al, 2012).

Problem statement

Academic and policy discussion of water management remains fragmented and often highly polarized. Water remains a crucial resource with significant international and transnational implications for its (mis)use. The purpose of this study is to evaluate the key polarities in this wider debate, examine its existing power relations and engage with- and chart a way through- the reality of current policy and praxis in light of normative imperatives.

Thesis Statement

The existing power relations dictating the water problem are heavily tilted towards corporate power, diminishing the capacity of the Human Right to Water to overcome contemporary barriers. The liberal theory of water availability ultimately proves to be a more fruitful point of departure for the configuration of a more effective global water management mechanism, including as it does the reality of current water management evolution in local and national contexts and accounting for the reality of non-state control of water resources.

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Research Question

Which approach improves water management more effectively and increases availability to populations in the face of existing power relations in the water predicament?

Research Objectives

To compare the two principle conceptual approaches to global water management through the prism of social power and existing power relations in local, regional, national and international scales by exploring the lenses of existing practices within a framework that challenges the normative hegemony of a rights-based approach.

Hypothesis

The Human Right to Water neglects the capacity to reform existing water realities and improve water availability.

Literature Review

The following section consists of a review of the existing literature on the water predicament, identifying its nature and challenges, the water governance gap, the role and power of the agribusiness, and the two emerging approaches to the water crisis; the idealist and the neoliberal. Water literature is often oriented towards actor-based or case study lenses, which risk enforcing the systematic disguise of power. While most literature reviews the crisis's historical roots or current state, this research will combine both and explore various sectors and scales in order to identify the origins of water's power relations and its prospects.

The Water Crisis: Human's transgression.

As the single integral component of development, change, and our very existence; the Water Crisis dictates global political economics and trading patterns. Due to the uneven geographical and economic distribution of freshwater resources, in addition to its varying values, and its conceptualization and quantification challenges; the current literature still struggles to promote a practical resolution to the water problem. Since most water is "abstracted, managed, and used at the regional to local scale" the crisis definition is argued and dependent upon "local socioeconomic, political, and hydrologic circumstances, the common global drivers of change, such as climate change, population growth, and globalization" (Srinivasan & et al, p. 1). Whereas Ritcher, Droogers, and Debaere target water scarcity caused by dietary norms, population, and industrial growth as its causes (2014; 2012; 2012), Ferreira and Júnior (2016)

 ISBN: 978-86-87043-85-5

regard historical choices in the field of economics and of policy concerning access, use, and the quality of water as its basis.

Natural distributions of resources will always exist, yet how institutions deal with these natural inequality dictates whether it is just or unjust (Rawls, 2009). Leading scholarship had increasingly recognized it as a "Water Management Crisis" (Bakker K. , 2010; Hall & Rogers, 2003). The Global Corruption Report of 2008 insists the roots of the crisis lies in corruption, which leads to undrinkable, inaccessible, and unaffordable water (Transparency International , 2008). In contrast, the 2021 UN-Water report steps back to the fundamentals of the problem and firmly argues that the inconsistent and unreflective value placed on water in all its different uses led to water's political neglect and mismanagement (UN Water, 2021).

Although the crisis definition remains debated and periodically revised, Srinivasans identifies its six 'syndromes'; "groundwater depletion, ecological destruction, drought-driven conflicts, unmet subsistence needs, resource capture by elite, and water reallocation to nature", emphasizing unsustainability, vulnerability, and chronic scarcity as its underlining forces (2012, p. 1). A vast amount of scholarship has attempted to uncover the crisis locus of power; Bakker (2010) and Cernison (2019) stressed the capacity of communities and governmental interactions, while the Union of Concerned Scientists targets private agribusiness influence as the determinate actors within water issues (2018). However, an actor-based approach is limited due to the inextricable linkages of water critical domains, which requires both an integrated theoretical and operational framework to ensure water availability, food security, sustainable agriculture, and energy production worldwide. Practices such as Water diplomacy, the HRW, and VWT emerged as political and economic short-term resolutions among states and large corporations (Carr & D'Odorico, 2018). Moreover, the World Water Council and UN-Water apply a long-term approach through various strategies and programs (e.g., water security, global changes, water governance, transboundary waters) (2021; 2021).

Poor Water Governance: From the National to the International.

Since half of the global population lives within the world's 310 transboundary river basins shared by 150 countries, equitable water governance is arduous (Michel, 2020). Excluding climate change, all determinative elements of a successful water regime, both national or global, are attributed to human social activity rather than a lack of technology or complexity (Burbach & Floress, 2019). Primarily raised in the development-environment debate, the literature broadly recognizes that Water Management (WM) is produced by and embodies "cultural values, historical context, and political realities" (Srinivasan & et al, p. 2), that had been customized to answer local contemporary demands rather than distribute water conservatively or equitably (Muller, 2015; Zilberman & et al, 2017). Furthermore, waters' asymmetrical physical global distribution results in disparate systems across countries.

Frequently, extractions' prices, agricultural practices, food pricing, and precisely whether the final product reflects its VW govern WMs schemes (Chittaranjan, Mclnnes, & Sanderson, 2018). Rogers and Hall list nonpayment for water services, ill-defined property rights, perverse

 ISBN: 978-86-87043-85-5

subsidies, inappropriate tax incentives, and special-interest effects as the dominant causes of WM failure in most countries (2003). McNabb insists that only diverse management models, designed under specific local needs and restrictions, will yield successful WM (2017). While Bakker underscores poor WM's socioeconomic, cultural, and ecological impacts, Molden highlights its power to propel environmental sustainability and social and economic development (2010; 2007).

Presently, the absence of a broader WM directive philosophy has resulted in ambiguous and exhausted systems that fail even the most water-abundant states (Colby, 2009). Jacobs et al. remark that once WM facilities are completed, the ability to modify them is severely limited (2016). Although Young notes that the traditional river-basin WM efficiently avoided continental mismanagement spillovers, it remained inadequate within the global context (Gordon J. Young, 1994). Moreover, as water-trade globalized and flourished, water production's location and uses expanded, transforming it into a global issue (Muller, 2015; Bernsen, 2011). Environmental protection and stakeholders' participation were appeased through the inclusion of Dublin's IWRM, as well as the Washington Consensus, supported by wealthy governments, the International Monetary Fund (IMF), and World Bank, which promoted privatization policies over state control (Muller, 2015; Bernsen, 2011). Nevertheless, by downplaying development and socio-cultural aspects, it neglected to satisfy all key actors (Muller, 2015). Its failure to achieve human development or environmental protection (Biswas, 2004; Suhardiman & et al, 2012), the global food and economic crisis (Benson & et al, 2015), and the interplay of actors and interests within the World Commission on Dams (WCD, 2000) led to the disappointing water policies of the 1990s and the rise of the Nexus approach as a pragmatic response (Muller, 2015).

Over the course of time a series of Nexus conceptualization had emerged from different sectors that places water in relation to different facets of its usage. Following are some of the dominant nexuses, although many others additionally emerged:

Nexus	Explanation	Definition	Authors
WFT	Water-Food-Trade	Derived from VW. Links water, food and trade policies.	(Allan, 2003), (McCalla, 1997).
WE	Water-energy	Emphasizes the reciprocal dynamic of water and energy.	(Scott & et al, 2011), (Perrone & et al, 2011).
WEF	Water-Energy- Food	Recognizes the links between water, energy and food in management, planning and implementation. Shifted WM from watersheds to problem-sheds.	World Economic Forum and the Bonn 2011 Conference. (Food and Agriculture Organization of the UN, 2014).
WEL	Water-Energy-Land	Evaluate land-use competition for agriculture, forests, human settlement and infrastructure, and biodiversity.	(Hatfield & et al, 2017), (OECD, 2021).
The Resources Nexus	---	Focuses on five essential resources: water, energy, minerals, food, and land.	(Andrews-Speed & et al, 2012), (Turton & Warner, 2002).

 ISBN: 978-86-87043-85-5

Despite of the proliferation of these nexuses, no single one captured the totality of the WM problem. The recommendations made in the 1970s became even more pertinent in the recent decades, begging the question why they were not acted upon accordingly and resurfaced as priorities (Muller, 2015). Although Muller asserts that it proves useful by "offering a polite way to move past Dublin IWRM" (2015, p. 686), he nevertheless joins that assertation that the nexus paradigm is incomplete and requires a single consolidating water governance (Purwanto & et al, 2021; Albrecht & et al, 2018).

Water and Agribusiness – political, economic and development implications.

In contrast to the agricultural sector, the Union of Concerned Scientists describe agribusiness as "the collection of vast corporate entities that control agriculture and food production" utilizing farmers' commodities as raw materials for processed foods, and "driving the trend toward large-scale, specialized, capital-intensive, mechanized farms" (Union of Concerned Scientists, p. 6). Thus far, the literature struggled to fully evaluate their role within broader political and economic structures due to their lack of transparency (Sojamo & et al, 2012; Newell & Levy, 2006). However, as state power shifted to private actors absent from democratic accountability (Krahmann, 2008), their substantial dominion over transitional food trade, VWT, and Water Security was gradually investigated (Sojamo & Larson, 2012; Murphy & et al, 2012; Larson, 2011). As principally profit-driven and heavily resourced agents responsible for 92 percent of global water consumption (Hoekstra & Mekonnen, 2012), their power across these intertwined sectors demands a more comprehensive understanding (Sojamo & Larson, 2012; D'Odorico & et al, 2019).

Murphy (2012), identified the 'Key agents', a western elite corporation that had become the most prominent traders of VW; ADM, Bunge, Cargill, Louis Dreyfus (e.g., ABCD group) and Nestlé. Sojamo estimates that the 'ABCD' holds a combined share of 23% of the global VW flows (2010). Whereas the ABCD are non-brand, privately or publicly held commodity traders, Nestlé is a branded, publicly traded company and thus prominent to civil society and its criticism (Larson, 2011).

Nationally, as witnessed in the U.S., the agribusiness sector invests generously in lobbying budgets and relationships with policy makers, ensuring the federal policy serves their interests (Union of Concerned Scientists, 2018). Internationally, trade globalization allowed corporates to consolidate water and land by manipulating food trade and pursuing vast land investments (e.g., Land Grabbing) (Hinojosa & Vos, 2016; Sojamo & Larson, 2012). Mehta (2012) examined how indebted smallholders are often forced to sell their land under unfair sharecrop arrangements and permissive environmental regulations. Likewise, it enabled corporate expansion through high-tech water and equipment investment (e.g., drip irrigation, water decontamination) (Hinojosa & Vos, 2016).

The agribusiness revels in the ungoverned and asymmetric global political economy by competing over market domination through political incentives and the coercive leverage of powerful lobby groups (e.g., U.S., EU, IMF), as well as mending direct positions at WTO and the World Economic Forum (D'Odorico, Carr, & et al, 2019; Sojamo & Larson, 2012). Free trade agreements, privatization of state-owned and community-held resources, and indirect federal subsidies allow to dictate trading norms and empower export production chains (Hinojosa & Vos, 2016). The Hydrosocial Territories introduced by Boelens et. al. as a theoretical tool contextualizes the multinational companies' power over natural resources (2016).

Sojamo and Larson (2012) distinguish their "instrumental power (e.g., influence via political lobbying and financing), structural power (bargaining position in value chains and in wider political agenda setting supported by material structures), and ideational and discursive power (ability to frame certain issues and debates)" (p. 623). Recognized as a regime actor in their own right (Okereke & et al, 2009) they can contest, resist, and build an inequitable transnational water governance regime (Levy & Newell, 2002). Ironically, Bunge and Cargill became the most prominent advocates for freer world trade while still receiving the most extensive agricultural subsidies and shares of food aid deals in the U.S. (Clapp, 2009).

The water problem is now recognized to be man-made, characterized by mismanagement rather than water scarcity, (mis)guided by poor national WM and absent global governance. Existing institutions are profoundly seized by the agribusiness sector, notably the ABCD and Nestlé. Yet, the literature remains fragmented in promoting a coherent crisis definition, a global governance paradigm, and a comprehensive analysis of the agribusiness public and hidden power. Consequently, two conceptual approaches emerged as a response. Evidently, none overpowered existing realities and ascended as a sufficient resolution. Although hidden data is argued to result in water's fragemented power analysis, the literature has fundamentally undertaken a case study and actor-based approach, which obscures broader critical assumptions. Nevertheless, water presently reflects global power relations; therefore, both approaches must be evaluated within the perceptual lenses of power, knowledge, and conflict.

Theoretical and Normative Perspectives: Power, Neoliberal and Idealist approach.

The following section explores the theoretical perspectives over power, knowledge, and conflict applied to the water predicament, followed by a comparison of its emerging approaches as reviewed by the literature.

Understanding how power works is the first prerequisite for action, *because action is the exercise of power*.

(Flyvbjerg, 1998 , p. 228).

Since its genesis, the water predicament was inherently shaped by power relations. The power embedded in water evolved beyond its existential force and manifested into global institutions and laws. The indispensability of water shared by all living beings alike requires its power dynamic to be clarified. Flyvbjergs' critiques of the ideal and the real;" what should be done and what is actually done" (p. 210), accurately reflect the water approaches enigma, the idealist vs. neoliberal[1]. By comparing Habermas and Foucault, Flyvbjerg examines the efficiency of consensus and conflict as catalysts of change. Flyvbjerg embraces conflict as a privilege and views its suppression as repression of freedoms. He critiques Habermas's communicative rationality approach, which advocates for constitutional writing and institutional reforms based on social consensus, as poor for its disregard for power relations.

In contrast, he favors Foucault's "power is always present" (1987) assertation and his evaluation of existing reforms through the empirical and historical process as means to unpack their power relations. Habermas idealist approach correlates strongly to the HRW; it emerged upon consensus, is aspired to be enshrined in the Declaration of Human Rights as its 'constitutional' grounds, and it lacks concrete regulative framework. Correspondingly, Foucault's approach directly unpacks the existing power realities of water that are reinforced through direct and hidden political, economic, and social conflicts. Flyvbjerg argues Habermas' approach is optimistic, slightly naïve, largely utopic, and severely uncritical of its constitutive realities. In contrast, he regards Foucault's approach as a means to identify contemporary barriers and promote change avenues.

Flyvbjerg postulates on Putnam assertion that "two centuries of constitution-writing around the world warn us… that designers of new institutions are often writing on water" (Putman, 1993), and concludes the law, its institutions, policies, and plans provide no guarantee of freedom, equality or democracy. Furthermore, 'neutral' institutions established precisely to shield 'public interest' are presently acknowledged as execution platforms of embedded political violence. This is demonstrated in the limited success of the HRW to overpower institutions and the governmental and institutional subornation to corporate power. Foucault asserts these exact social systems turned freedom into theoretical formulas, which is too perceptible in the HRWs failure to suppress theoretical grounds and propose a practical reform.

Flyvbjerg seeks to reduce the gap between intentions and their implementation and embraces Francis Bacon's "Knowledge is Power," yet emphasizes "not only knowledge is power, but more importantly, power is knowledge" (Flyvbjerg, 1998, p. 319). Flyvbjerg contends knowledge and power exist in a communicative, yet asymmetrical, relationship; thus the more rationality, the better[2]. Through Flyvbjerg and Foucaults' examination over what counts as knowledge and what interpretations become our authoritative reality, the constructing reality of water could be understood.

[1] The following sections which present Flyvbjergs' comparison of Habermas and Foucault relies heavily on (Flyvbjerg, 1998).
[2] The following sections examining the power-rationality relationship and its deduced propositions, relies heavily on the insights of (Flyvbjerg, 1998).

Flyvbjerg builds on Machiavelli, Nietzsche, Kant and Foucault, extending propositions that identify rationality and power construction; power is the dominating context of rationality, power defines reality, rationality often lives within contextual power, rationalization presented as rationality is a principal strategy of power exercise, the greater the power the less the rationality, stable power relations are more typical in policies than antagonistic confrontations, these are constantly being produced and reproduced, powers' rationality is historically profoundly rooted, rationality yield to power in open confrontations, and lastly he recognizes their relations are evident and embedded in stable power relations rather than confrontation. This paper offers an analysis of the conceptual approaches from the standpoint powers analytics is more effective in understanding reality than the Idealism of the rights-based approach.

A Comparison of the Literature

Various approaches emerged as a pragmatic response to the water predicament. As water reached numerous research fields, from law to economics, it fueled the fierce debate over the approaches, each prompting the other (Cernison, 2019). Amongst them, the idealist approach and the one generally understood as the neoliberal approach evolved as the two predominant and conflicting paradigms. The latter suffers from 'conceptual confusion' that arises due to "a lack of analytical precision about the wide range of ongoing reforms", notably privatization, marketization, and reregulation, which are often inaccurately labeled and over-simplified into a monolithic "neoliberalism" (2007, p. 433). Failure to adequately compare similar cases portrayed reforms as interchangeable and distinct practices were assumed to be synonymous (Castree, 2005). Biophysical properties, as well as governance framework, dictate the type of reforms; fisheries are amenable to marketization, while supply networks are better suited to privatization (Bakker K. J., 2004; 2005), although Cernison insists privatization is the extreme example of neoliberalism, rather than its norm (2019).

Consequently, anti-privatization campaigners problematically contrasted Human Rights as an antonym to 'commodities' instead of 'commons' (Bakker K. , 2007). Water activism, referendums, unilateral reduction of bills, and urban guerrilla activities shaped and accelerated the rise of the HRW and the growth of VWT alike (Cernison, 2019). As such, the Alter-globalization paradigm emerged, counterposing 'commons' models of resource management (Bakker K. , 2007).

Neoliberal Approach.

The commodity approach distinguishes private ownership and WM from water itself, deploying a market-oriented approach to water, treating it as an economic good that should be fully priced and requires utility services (ICWE, 1992). D'Odorico, Carr and Garcia-Ramon assert the nature of water difficulties is one of market with regulated trade as an appealing

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solution (2017; 2019). Following the 1980s 'Lost Water Decade,' Dublin's Principals and Kyotos Declaration, waters' integration into markets, industrialization, and private investments were eagerly received by intergovernmental institutions and states during the nineties (Cernison, 2019; Liotard & McGiffen, 2009; Bakker K. , 2007). 'Liberal Environmentalism' (Bernstein, 2001), 'Green Neoliberalism' (Goldman, 2005), and 'Market Environmentalism' (Bakker K. J., 2004) emerged as a corollary to this paradigm.

Its proponents, namely private companies and bilateral aid agencies assert that this approach first and foremost increases WM efficiency (Cernison, 2019; Hall & Rogers, 2003; Winpenny, 1994). Furthermore, it simultaneously addresses environmental degradation while embodying waters' value (Shirely, 2002; DFID, 1998). It holds public actors as politically motivated, financially restricted, and incapable of rectifying the unsustainable WM, and insist the private sector should be permitted to upgrade water system through lowering prices, increasing cost recovery, and improving systems performance (Savedoff & Spiller, 1999; Bakker K. , 2007; Cernison, 2019). Redefining citizens as users re-allocates the attenuated political accountability to the direct private accountability that is subordinate to both customers and shareholders alike and is able to bolster water conservation through pricing (Bakker K. , 2007; Hall & Rogers, 2003; Winpenny, 1994).

In contrast, its critics resist the market perspective to WM, arguing it diminishes the Human Right to Water (hereafter 'HRW') and lowers waters availability to citizens (Gleick, 1998; Trawick, 2003; Bond, 2002). Anti-dams' activists, international bank- watchers, and anti-globalization think-tanks argue that giant multinational corporations focus on accumulating profit and invest strictly in urban economically prosperous context, with the support of captured 'neutral' international organizations as the World Bank and the World Water Council (WWC) (Cernison, 2019; Taylor, 2005). Extended literature explores its multidimensional negative aspects caused by neoliberalism' "accumulation by dispossession" (Glassman, 2006). Concerns over their subordination to profit-motivated shareholders favor democratic accountability over corporates' self-regulation. They conclude this approach doesn't necessarily solve or even reduce water inefficiency or expenses but instead increases both in the case of unsuccessful privatization (Liotard & McGiffen, 2009; Public Citizen, 2003). Financially, water is seen as an 'uncooperative' commodity, nonexcludable yet rival in consumption, localized in nature, community-controlled, and thus associated with 'market failures' (Mehta, 2003; Bakker K. J., 2004). Furthermore, global concerns; power imbalance among states, arid countries dependency on trade, common knowledge distortion, and fear over 'a race to the bottom' became increasingly debated (Warner, 2003; Bernsen, 2011). Estache and Rossi (2002) finally asserted that the market approach is incompatible with the HRW, however, Bakker (2007) demonstrates that private sector provision is indeed compatible with the HRW if coupled with a universal requirement, price control, and quality standards.

Idealist Approach: The Human Right to Water (HRW).

 ISBN: 978-86-87043-85-5

The right to water entitles everyone to have access to sufficient, safe, acceptable, physically accessible and affordable water for personal and domestic use

(UN-Water, 2021).

The Human Right to Water transforms the basic need for water into a rightful claim, legally enforcing its legitimacy, authority, and state compensation[3]. Its conceptual framing expands its universal reach and empowers individuals' agency and dignity as right holders, providing a compelling and coherent base to water claims. Being recognized as a basic need doesn't alone classify it as human right, but rather its legal acknowledgment which guarantees the state's legal obligation and accountability (Bourquain, 2008; Sultana & Loftus, 2015). The campaign for the HRW, which formalized upon growing water scarcity and the rise of the commodity's paradigm and privatization schemes, attempted to fill the existing gap within the human rights framework (Cernison, 2019). Relaying on research insights provided by Elinor Ostrom, activists proposed the commons approach, which "goes beyond the traditional, uncontrolled public management model" (Cernison, 2019, p. 77; 1990). The HRW legal basis is complicated; it is explicitly absent from the Declaration of Human Rights, as water was considered an infinite resource, like air, and thus wasn't considered in need of enshrinement. The right was partially recognized in the International Covenant on Economic, Social and Cultural Rights (Social Covenant/ ICESCR), as well as the International Covenant on Civil and Political Rights (Civil Covenant/ ICCPR), yet it wasn't done so explicitly, but rather as an underlying determinant of the right to health and housing (Sultana & Loftus, 2015).

However, in 2010 the UN General Assembly ultimately adopted a resolution that "recognized the right to safe and clean drinking water and sanitation as a human right that is essential for the full enjoyment of life and all human rights" (General Assembly, 2012), further confirmed by the UN Human Rights Council which;

> Reaffirms that *States* have the *primary responsibility* to ensure the full realization of all human rights, and that the delegation of the delivery of safe drinking water and/or sanitation services to a third party does not exempt the State from its human rights obligations.
>
> (Human Rights Council, 2012).

Symbolically departing from the 1992 Dublin principles, the WHO, UNDP, and UN Economic and Social Council endorsed the right, which was further integrated into the SDGs (ICWE, 1992). Its integration into the Human Rights regime transformed international discourse, reflecting global societal power relations (Bielefeldt, 2006).

Its proponents, namely anti-privatization activists, indigenous communities, and global organizations as the UN value waters as essential for life. They argue that democratic accountability will increase citizen participation, open new legal avenues for water claims and

[3] The following section which reviews the Human Right to Water relies heavily on the insights provided by (Winkler, 2012).

promote more efficient and green use of water (Estache & Rossi, 2002; Bond, 2002; Goldman, 2005). The World Water Forum in Kyoto and Mexico marked the rising support of senior water industry representatives, notably the World Bank and private corporations, who began advocating for the HRW publicly, signifying the civil, governmental and private sectors consensus (Salman & Mclnerney-Lankford , 2004). Bakker recognized it as a welcomed strategy for resolving the urban water crisis, as it acts as a transformative discursive tool and measure of standardization (2010). However, she points out that its inherent focus on vulnerable groups creates powerful means to combat the "elite capture" of water systems (2010). Whether motivated by global production or the sustainability of related rights motivated such, the HRW became an international stand on water.

However, its legal basis and lack of regulative conceptual clarity is heavily criticized. Firstly, it creates tensions when coupled with traditional (communal) water rights that are immensely important for indigenous populations (Bakker K. , 2010). Although the Human Rights Declaration omits binding coercion, it maintains symbolic power if not an intentional commitment. Because the HRW isn't explicitly stated, its legal premise is rendered inferior to other rights. Furthermore, given that its incorporation into the South-African post-apartheid constitution failed to achieve equitable water availability, the lack of clear responsibility and capacity for implementation was identified as its principal shortcoming (McDonlad & Ruiters, 2005; Bond, 2002). Absent a formulated regulative framework; the right remains merely an honorable moral statement rather than a solid solution to a management shortcoming. Other obstacles, such as "the possibility of causing conflict over transboundary waters; and potential abuse of the concept as governments could over-allocate water to privileged groups, at the expense of both people and the environment," further question its capacity to achieve change (Bakker K. , 2007, p. 438).

Furthermore, the HRW doesn't ultimately foreclose privatization schemes or assure free or equitable access and distribution of water in most liberal states. Its vivid support by private corporations indicates upon its inability to truly resist the global power imbalance (Dubreuil, 2005; Bakker K. , 2007). Supporters of alter-globalization condemn the "rights talk" as belonging to an individualistic, Eurocentric libertarian philosophy that excludes possibilities for collective action beyond corporatist models of service provision and reinforces the public-private binary of the water predicament (Olivera & Lewis, 2004; Shiva, 2002). Similarly, its anthropocentric nature fails to account for ecological actors that might further demolish hydrological systems (Bakker K. , 2007; Shiva, 2002). Thus, this approach can be both exclusive and regressive, along with inclusive and progressive (McCarthy, 2005). Lastly, the right inherently ignores communal power relations and instead romanticizes them as coherent and fair social structures (McCarthy, 2005; Mehta, 2001).

This directly supports Flyvbjergs' assertion over the shortcoming of idealism to match the power existing in reality. He cautions that Idealist notions of what reality should be like are a weak basis for evaluating the contemporary state of affairs, and more importantly, its modification outlets. Its inherent neglection of power relations renders it utopian and naïve rather than realistic and informative and thus constitutes a poor analytical basis for resolving

 ISBN: 978-86-87043-85-5

real-life issues as the water predicament. The analysis demonstrates that the literature is not sufficiently inclusive of the reality of the current water management praxis, rendering the rights-based approach inert as an organizing principle. Thus, power analytics emerge as the most compatible avenue of exploring and resolving the predicament.

Research Design.

In this research, I will employ comparative analysis (AC) methodology within political science. This analysis explores political systems, institutions, and processes and through local, regional, national, and international scales through comparison of equivalent elements. For the present research, we explore two normative frameworks in the issue of water management in comparison. This methodology allows us to seek a better political understanding beyond the mere ideological or theoretical discourse. Because the nature of the water problem evinces various practical political concerns, this method proved the most sufficient. I will unpack the water problem by reviewing its dominant political institutions and processes, basing evaluation on both conceptual critique and empirical evidence derived from open-source data. I will perform a comparative conceptual analysis of the dominant frameworks for WM by illustrating through examples the successes and failures of the approaches to respond to the water problem. I will rely heavily on the theoretical insights provided by Flyvbjerg and Foucault as means to explain the power relations embedded within the issue. Essentially, the paper undertakes analytics of power in order to elaborate on the efficacy of both conceptual frameworks and draw a conclusion about which is more effective in achieving the goal of competent water management.

Analysis

The International Governance and the of the UN.

The water predicament is now understood to derive from governance shortcomings and absences. Schnurr defines global water governance as “the political, economic and social processes and institutions by which government institutions on all levels - international, national, regional and local, civil society, and the private sector make decisions about how best to use, develop and manage water resources in order to achieve internationally agreed-upon goals, thereby applying the principles of ‘good governance’” (2008, p. 114). Officially introduced in 2004, the concept of Global Water System (GWS) attempted to bridge across water sectors and agents (C. Vörösmarty, 2004). However, the global water arena lacked the interests, pressures, and institutional consolidation that is foundational for an emerging water regime (Muller, 2015), making it prone to manipulation and “elites capture” (Sojamo & Larson, 2012).

 ISBN: 978-86-87043-85-5

While some view Water Governance as an academic concept (Ünver, 2008; Bernsen, 2011), transnational corporate networks and leading agencies are nevertheless seen as an emerging regime (Sojamo & Larson, 2012). Regardless, their profit-driven nature and limitations over resolving critical human dimensions of WM are well-acknowledged (Burbach & Floress, 2019). Various authors suggested a range of global institutions promoting equity and resource efficiency; water pricing protocol for product, water footprint quotas, and labeling/taxing water-intensive (Hoekstra, Mekonnen, & et al, 2011; Hoekstra & Chapagain, 2006; Verkerk & Hoekstra, 2008; Hoff, 2009). McKay (2003) goes so far to propose a VW Trading Council within the WTO to redistribute water resources on ethical grounds.

The existing interplay of supposedly neutral international organizations (e.g., World Bank, UN-Water) and multi-stakeholder organizations (e.g., World Water Council) is criticized as ineffective, partisan, and obscure (Shiva, 2002; Public Citizen, 2003). The World Bank, recognized by activists as prime private-sector advocates, initiated short-termed engagements (e.g., loans, committees) that shaped WM indefinitely, yet neglected to institute the necessary regulative framework (Srinivasan & et al, 2012; Sojamo & Larson, 2012; Shiva, 2002). UN-Water, the Sustainable Development Goals, or the CEO Water Mandate, only encourage and recommend water regulation yet are unable to impose it (CEO Water Mandate, 2021; UN-Water, 2021). The World Water Council, an international umbrella organization composed of corporations, institutions, and organizations, attempted to unite water governance under the World Water Forum. However, its informal ministerial meetings of business-based NGOs and large corporations were seemingly controlled by the private sector who advocated for greater participation policies, namely the ‘Bonn Keys’ (IRC, 2001);

> The Forum’s orientation is profoundly influenced by private water companies. This is evident by the fact that both the president of the World Water Council and the alternate president are deeply involved with provision of private, for-profit, water services (UN, 2009).

This displays Flyvbjergs assertation that in open confrontation, rationality yields to power (Flyvbjerg, 1998). Ironically, during the Forum, the code of conduct concerning corruption was proposed by nonetheless the private actors (IRC, 2001). Its failure to represent and consolidate key actors resulted in a parallel series of counter events known as the Alternative World Water Forum dominated by water activists (Cernison, 2019). Consequently, national and global water governance remains unbinding, unregulated, and easily manipulated. Flyvbjerg's proposition, that power is exercised by presenting a specific rationalization as rationality, questions whether the agribusiness hadn’t deliberately ‘sacrificed’ themselves to scrutiny in the Forum as measures to conceal their remaining hidden power (Flyvbjerg, 1998). While privatization schemes were singularly battled upon, the private sector constantly shaped WM in to its current, weak legal form, incapable of supporting the HRW. Although these measures are unlikely to be ever disclosed, their success is nevertheless an impressive exhibition of power.

Despite the international nature of water, it is doubtful that the current international system, shepherded by the UN, could be its salvation. Although Human Rights emanated from the UN,

 ISBN: 978-86-87043-85-5

a precedent for a successful 'rights'-based approach is not evident. The UN has never independently enforced rights but only executed and regulated its international affairs mandate. Its capacity to act as a catalyst for change is dictated by its member states. Unless the states endow the UN with the power to do so, the UN remains an ineffective catalyst for water issues. Furthermore, its increasing dependence on voluntary contributions for selected activities weakened its ability to execute its mandated programs (UNJIU, 2007). Harris and Mirosa (2012) stress that for any successful water governance, the challenges, opportunities of provision, end goals, and accountability, must be specified. Given the UN's empirical difficulties to adequately assess and conceptualize water's value, elementary individual quantity and suitable quality, its competency to resolve the existing regulative difficulties is arguable. Financially, the UN capacity is severely lacking; its budget for 2020 stands on $3 billion alone (UN Affairs , 2019), while the federal US budget dedicated solely to agriculture stands on $20 billion (U.S. Congress, 2019), and Nestlé Group's sales worldwide stand on $90 billion (Wunsch , 2021). Since "Knowledge is Power", the UNs empirical deficiency further adds on its financial limitation and renders it relatively powerless to private actors (Flyvbjerg, 1998).

Notwithstanding the value of the SDG goals and the Declaration of Human Rights as noble theoretical landmarks, their recurrent colossal violation questions the UNs efficiency to champion the HRW under legal coercion. Moreover, the rights static characteristic is incapable of responding to swift climate variations that transform the global water terrain overnight (Bakker K. J., 2004). Sangameswaran discerns the "international human rights regime as a relatively strong promotional regime [and] a relatively weak implementation regime" (2007, p. 9), emphasizing the UN's inherent regulative power limitation. This directly corresponds to Flyvbjergs' notions over the weakness of idealism in implementation schemes (Flyvbjerg, 1998). His critique asserts that the mere ideals represented within the HRW, as inspirational as may be, do not provide the conditions for its implementation, rendering the HRW powerless (Flyvbjerg, 1998).

Bakkers further expresses concern over the individualistic, Western, state-centric, anthropocentric, and universalistic basis of 'rights talk' (Parmar, 2008), to deal with critical ecological challenges faced by marginalized, indigenous, and non- Western populations (2007; 2010). Moreover, rights reinforce the very framework that reproduces water's unequal power relations (Sultana & Loftus, 2015). Flybvbjerg recognizes that rationalization presented as rationality creates an "untouchable" position that is later hard to penetrate (Flyvbjerg, 1998). Although the HRW recognizes the larger theoretical and holistic elements of water and supposedly facilitates various actors in the discussion, the UNs reliance upon the member states as responsible water agents omits their subordination to private corporations.

State Responsibility and Irresponsibility.

 ISBN: 978-86-87043-85-5

The global indifferences that arise from the HRW are further challenged with the current complex reality of poor national WM. The HRW allocates responsibility over to the state, yet neglects to recognize the state as the de facto custodian that it is. It exclusively obtains from proposing a feasible implementation scheme capable of consolidating entangled policies, agencies and international treaties. While governmental water policies should reflect social factors as equity, water rights, attitudes, norms, and values, guided by scientific projections, they are often the results of economic and political imbalances (Burbach & Floress, 2019). Subsequently, federal water policies became administrative substitutes for marginal tinkering with the status-quo, further discrediting state capacity to administer water (Stakhiv, 2003). Moss and Newig further observe that "levels of government and administration typically do not fit the environmentally relevant scales, resulting in inefficiencies, spatial externalities and spillovers" (2010, p. 1). Financially, state agencies hardly possess the means to advise, much less implement, top-down institutional changes, providing insufficient solutions to an outdated system (Stakhiv, 2003; Cernison, 2019). Thus, the poor WM of states is unlikely to revolutionize abruptly. This once more correlates to Flyvbjerg's insights on the normative tendency to neglect what is actually the case in reality and instead favor what should be the case (Flyvbjerg, 1998).

The failure of contemporary WM stems from historical development, structural challenges, and a highly centralized decision-making platform. Modern policies developed over decades of historical agricultural necessities, institutionalizing the massive existing system of dams, reservoirs, and aquifers, which ultimately reshaped the natural water cycle (McNabb, 2017). Consequently, the existing infrastructure permits little room for modifications, turning water management to a temporary ‘patching’ system and increasing local political clout (Burbach & Floress, 2019; Floress & et al, 2015). Wider transnational strategic water management has become its main casualty. Savedoff and Spiller describe state moderation as an increase of workers and salaries while fixing prices at an unsustainably low level (1999), that fails to create an incentive for water conservation or investments and derogates the overall welfare (Lachman & et al, 2016). Lachman et al. show, for example, how farm irrigation water supply neglects to factor in cost associated with federal subsides infrastructure (2016). As WM infrastructure periodically expended, so did its legal complexity. Conflicting water rights accumulated into a complex legal ‘bundle rights’ reflecting the inconsistent legislation and its selective interpretation (Abukhater, 2013). Foucault cautions that selective promotion of a chosen interpretation favors power actors and reproduces knowledge and, in turn, reality (Flyvbjerg, 1998). Ribot and Peluso further argue that natural resources'' disproportionate benefits are rooted in access and poverty differences, where the former embodies ‘bundle of powers’ and the latter ‘bundle of rights’ (2003).

The centralized, elite-dominated, and intentionally ambiguous decision-making platform further diminished chances of its reconciliation or water conservation (Lewis & Benton, 2008). Favoring engineering factors over social and environmental elements meant citizens' engagement was systematically blocked and deprioritized (Burbach & Floress, 2019). The use of scientific and engineering discourse has had the dual effect of excluding non-specialist stakeholders and users from meaningful engagement in policy making and simultaneously

 ISBN: 978-86-87043-85-5

enabling what are effectively political acts a veneer of scientific justification. Therefore, it could be argued that while political decision-making is scientifically informed, it is not sociologically informed. This systematic knowledge creation inherently dictates water power relations (Flyvbjerg, 1998).

Disconnect between national-level decision-making and local communities is exacerbated because local actors found the information to be inaccessible and difficult to comprehend, limiting their capacity to influence. Although Watershed Councils and River Basin Commissions were established precisely to bridge over the existing knowledge gap among the stakeholders, they fail to accommodate non- agricultural water users (Jacobs & et al, 2016). Vast amount of scholarship views unequal access to water as a cause of power imbalance within WM (van der Zaag , 2007). Thus, politicians' agendas easily overpowered scientific recommendations or economic interests, resulting in resources overallocation and rights maneuvering (Savedoff & Spiller, 1999). Presently, a single agency cannot independently pursue major water policy reform through its legislative channels. Consequently, institutional modifications are fought over indirectly through project planning processes (Stakhiv, 2003). Absent the necessary legislative authority to accommodate changes; large projects result in add-on features targeted to satisfy numerous interests with veto power (Stakhiv, 2003). This exhibits Flyvbjerg's assertion over the ability of power to shape reality through knowledge proliferation.

State water management in many nations has emerged for the most part in an ad hoc, organic, piecemeal, short-termist manner, which has not incorporated sufficient strategic foresight to allow for the alleviation of increased demand or ecological challenges. This has now been compounded by the neo-liberalization of water provision as a public good, where those with a claim to water 'rights' have become water 'consumers', and where a cost-benefit and exchange modality has further complicated effective water management (Ginsberg, 2004). Communities selectively engage agencies capable of offering them the best deal for their local water difficulties rather than conferring the regional management compact (Stakhiv, 2003). These patterns indicate the economization and politization of water from its holistic, abundant and common perspective to a marketized, rationed and private source, where government legitimizes water privatization. Thus, the present rationality of WM had been deeply rooted in power exercised in historical junctures (Flyvbjerg, 1998).

Federal WM privatization has been argued to increase the 'efficiency' of water system, however, efficiency's benefits don't necessarily imply reduced costs of provision or improved water quality (Bakker K. , 2007). Furthermore, private firms inherently prioritize profit as their end goal, often disregarding implications of actions for end-users by promoting diverse and often inconsistent goals (Sojamo, 2010). States such as Chile, which fully privatized their water resources, institutionalized theft by favoring extractive industries over the community's water rights (Civicus, 2020). Although the constitution preserves water ownership, its interconnectedness to privatized sanitation deepens the evident democratic deficit. Nowadays, Chiles' citizens pay the highest rates in Latin America for drinking water, commanded by western transnational corporations such as the Suez group and the Canadian Ontario teachers'

pension fund (Civicus, 2020). Similarly, England and Wales invoked privatization transition during the 1970s as federal water systems were "starved of funding, failing to deliver a good service and damaging the environment" (Thomas, 2020). Drowned in pollution and poor-quality drinking water, the newly formed Regional Water Authority (RWA) reallocated responsibility from local water boards to a handful of private companies that indeed improved its poor quality (Hukka & Katko, 2003).

The rise of privatization schemes globally could be argued to indicate the incompetency of most states to institute WM, while simultaneously displaying the extension of corporate power through lobbying of executive control over water systems. Given the emergence of anti-privatization campaigns globally, as in Paris, Berlin, and Cochabamba (Cernison, 2019), one could hardly argue it's an appealing resolution to all actors, particularly local communities. The adoption of the HRW discourse by private companies further signifies its restraint as an anti-privatization strategy as it doesn't oblige subsidies to poor communities or equitable redistribution (Sultana & Loftus, 2015). Thus, the HRW is not only found to be inadequate to resist such schemes (Zilberman & et al, 2017), it is also found to be compatible with private-provision in neoliberal states (Bakker K. , 2007). Thereby, the HRW theoretically empowers state responsibility, but states had already attempted to be released from this responsibility, either by their own free will or through lobbyism that encouraged this transition. States had long recognized their failure to handle water issues, resulting in privatization. Thus, even 'purely' federal schemes might be very well the result of private interference in states policies.

The Non-State Sector: Corporate Interests and Policy Capture.

Power is *always* present.

(Foucault, 1987)

Local

Corporate agribusiness control is firstly transmitted from the international level to the local. Corporate's domination over water, food, and energy's global trade markets shapes local farmer patterns. Through their global market dominance, corporations determine local crop prices and purchasing restrictions that affect local competition, farming security, livelihood and diversity (Clapp & Fuchs, 2009; Hendrickson & Heffernan, 2002). Presently, structured overproduction, globalized competition and the external costs of industrial processes damned farmers to pitiful profits due to low crop prices (Graddy-Lovelace & Diamond, 2016). Corporations not only command crops prices but also set a precedent for farming trends. Through vertical integration of the various supply chain stages, they provide the farmers with specific seeds and fertilizers, guaranteeing supply to their trading operations and manufacturing facilities (Sojamo & et al, 2012).

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During the 90s, developing states increasingly welcomed foreign investment as means to advance their capital and trade (Garcia-Ramon, 2019). Surfacing as the Land Grabbing phenomenon, developed states and corporations enthusiastically indulged in acquiring vast agricultural and water-rich lands (Mehta & et al, 2012). Exacerbated by the 2008 Food Crisis, their swift entrance into small-scale agricultural production networks had expedited pesticides water pollution, resources exploitation, and animal waste, exaggerating local competition and driving local farmers to debt or displacement (Sojamo & Larson, 2012; Agrawal & et al, 2010; Mehta & et al, 2012). Small farmers unwillingly sold or leased their land to large corporates while others did similarly with their water rights (Zoomers, 2010; Garcia-Ramon, 2019). However, since many states exempt agricultural uses from permit requirements (Water Law: An Overview, n.d.), corporates freely exploited water resources in their countries of operation.

The development of the global agricultural trade stimulated transitional quality and safety standards. Corporate technological capacity increased the power imbalance between farmers and corporations, who reduced production costs to those who could financially qualify their standards (Garcia-Ramon, 2019). The corporates' accessibility to fast-developing bio-technologies overpowered indebted local farmers who were forced to turn over property rights to companies such as Cargill and Monsanto to pay for the expensive seed the companies' policies imposed to begin with (Garcia-Ramon, 2019). Furthermore, corporations capitalized on senior water rights, often exhausting their permits' consumption rates and operational duration (Lawrence, 2021; NBC News, 2018). By employing low-cost strategies, like donating to local youth groups or winning over small-town officials with attractive water rights, they cement investments and relationships that potentially could last a century (Bernsen, 2011). Ultimately, local actors, who are key actors for efficient WM, become defenseless to the top-down and direct pressures of giant corporations. Their power has carefully been rooted, systematically enforced and orientated towards long-term effects through mechanisms of knowledge and possession, molding the very tangible reality of disempowered local actors (Flyvbjerg, 1998). The agribusiness sector further ensures its supremacy through national channels.

National.

Nationally, agribusiness corporations possess immense bargaining power over political entities as the most profit-driven stakeholders in the water distribution systems. Ritcher (2014) recognizes that water corruption takes many forms, which are often more subtle than outright bribery. Through close interactions with national trade organizations and extensive federal lobbying, the agribusiness corporations successfully shape national export and import policies as well as indirect federal subsidies (Magdoff & et al, 2000). In the past, elected candidates were incentivized by voters' water demands, utilizing water as a vote catcher (Ritcher, 2014). Nowadays under agribusiness lobbying, water projects have become a political currency, rigorously traded in federal halls for favors and votes, advancing corporate interests (Rocky Mountain PBS, 2020; McCool, 2012). Thus, the idealist premise of the state's duty to serve and

protect its citizen is severely tempered by the fact states' rationality yields to corporates' power (Flyvbjerg, 1998).

The seeds of the agribusiness lobby in the U.S. are traced back to Nixon's era when agricultural secretary Butz, who was heavily influenced by major corporations, urged farmers to either "get big or get out" of farming, increasing the industrialization of food production and consolidating control to a number of corporations (Philpott, 2008; Union of Concerned Scientists, 2018). The U.S. agricultural lobby exercises control by devoting generous lobbyist budgets and political contributions to Congress. In 2020 alone, 493 agribusiness entities employed 1144 lobbyists, of which nearly 60 percent were former governments employees, who invested a total of $142 million in agribusiness (OpenSecrets, 2021). The 'revolving door,' whereby former government employees went to work for lobbying and consulting firms while corporate lobbyists took government jobs, empowered the agribusiness to become a robust force within the political terrain through systematic massive investment mechanisms (Union of Concerned Scientists, 2018);

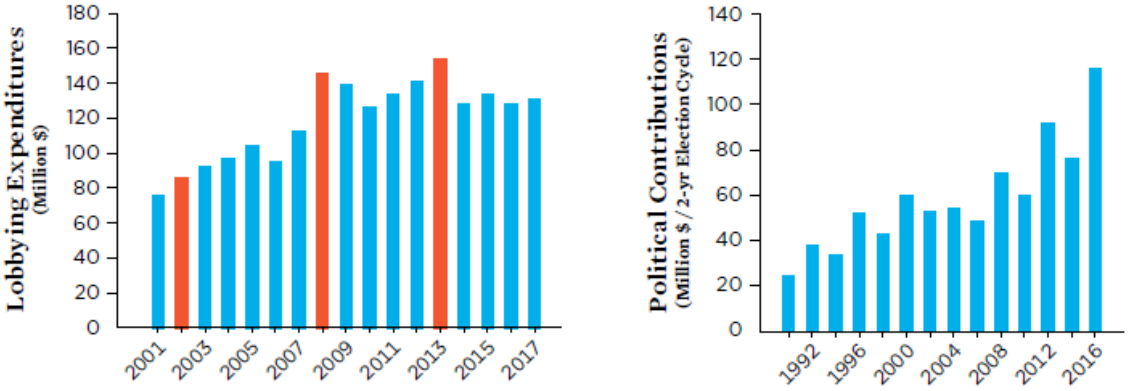

Figure 2 & 3. U.S. Agribusiness lobbying by expenditure and contributions, presented by (Union of Concerned Scientists, 2018).

Similarly, the United States Department of Agriculture (USDA), responsible for developing and executing farming, forestry, and rural economic development policies, has been systemically stocked by underqualified profit-driven individuals and a leadership exclusively composed of agribusiness officials[4]. Similar patterns are seen in other water-rich regions. In Peru, the National Water Authority (ANA) failed to monitor the overexploitation of the Ica region in the face of agribusiness elites' resistance, who successfully became the region's dominant economic and political actors (Damonte, 2019).

Another form of agribusiness power is indirect federal subsidies[5]. In the U.S., following the Great Depression, Congress applied the 'Doctrine of Parity', which standardized commodity prices and paid farmers to set aside land to constrain overproduction (Graddy-Lovelace &

[4] The following section, discussing the US agribusiness lobby, relies heavily on the insights provided by (Union of Concerned Scientists, 2018).
[5] The following section exploring US indirect agricultural subsidies relies heavily on (Carlisle & et al, 2019).

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Diamond, 2016). When aggressive agribusiness lobbying eroded supply systems, corporations such as ADM and Cargill replaced parity policies by mandating farmers to over-grow grain rather than vegetables or fruits. The federal government promised direct and emergency payments to assist the farmers, serving as indirect subsidy to agribusiness. This chronically altered US agriculture and entrenched federal funding to this day. Although fragmented data mainly hide corruption, its global premise is still prominent:

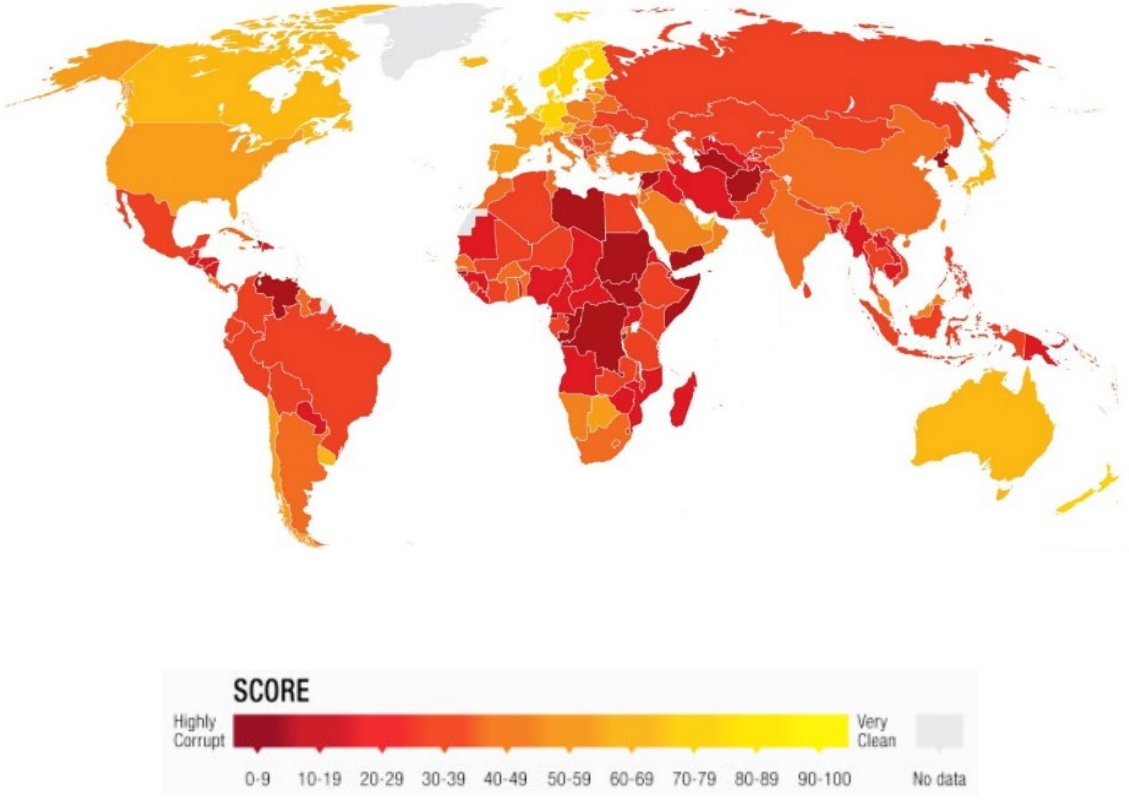

Image 1. Corruption Index 2020, as provided by (Transparency International, 2021).

Based on experts' and businesspeople's observations of levels of public sector corruption, governmental corruption is on average 43/100, with over two-thirds of the 180 researched countries scoring below 50/100 (Transparency International, 2021). Although this serves as a firm indicator for state capture, their full power will remain hidden until private corporates disclose their operations data. Flyvbjerg (1998) contends that 'A party's unwillingness to present rational argument or documentation may quite simply indicate its freedom to act and its freedom to define reality' (p. 321), as can be seen in the corporate's reality. He considers the absence of such as 'more important indicators of power' (1998, p. 321) than the actual arguments and documentation produced. Nevertheless, the existing data and the emerging democratic deficit questions state's capacity to act as a reliable agent to the HRW (Bekker & et al, 2007). Whether water systems are indirectly, yet 'legally,' influenced by powerful lobbyists, or federal WM is simply insufficient, entrusting contemporary governments with water responsibility is flawed. It is worth noting that, while it is easier to trace corporate power nationally, their power is even substantially unchecked internationally.

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International.

Internationally, corporations exercise their power relatively discreetly within the ungoverned global water arena. Although they're not forthcoming about their activities, their power over the international political economy is projected through VWT. Hoekstra and Mekonnen recognize that globally industrialized agriculture is accountable for 92% of water consumption, influencing water ownership and security, land investment, and the trade of food and VW (Arjen Y. Hoekstra, 2011). As the market globalized, corporations such as the ABCD group evolved to entities resembling banks, trading in commodity exchanges which increases concerns over the potential for a westernized oligopolistic abuse of market power (Murphy & Burch, 2012).

In almost every key sector of the food system, four firms alone control 40 percent or more of the market, and their concentrated power discourages sustainable agricultural initiatives unless these serve corporate interests (Howard, 2016). The fact that so much of the market is held in private hands also conceals critical water data that could advance contemporary assumptions about the water predicament (Oxfam Research Reports , 2013). Their institutional capacity of finance and hedging further empowers them to freely exercise market power (Kaufman, 2011). Since food politics remains primarily un-scrutinized in the international arena, western market hegemony isn't directly challenged (Sojamo & et al, 2012). Consequently, water resources transactions among nations, private actors and consumers ultimately became a marketplace issue. Evidently, corporate control is the rationalization of power. By promoting its supremacy with little or no justification, it transforms the nature of discussion away from the idealist perspective of the HRW to economic realities. This vindicates Flyvbjergs' argument over realpolitik and idealism; reason will never win against power in a fair fight, nor will it reach such conditions (Flyvbjerg, 1998). Foucault's notions about the reproduction of reality through power imbalances, further demonstrates the incapacity of the HRW idealism to ascend beyond its power relations (Flyvbjerg, 1998).

The precedent of this consolidated power was institutionalized through the globalization and liberalization of markets. Corporate dominance is traced back to the Cold War era where western corporate hegemony imposed an 'hour glass market', resulting in the current extensive grain growth (Friedmann, 1993). However, it was not until the nineties that agro-industrialization rapidly globalized due to urbanization and neoliberal ideologies (Barret & Reardon, 2000). Market-oriented economies and the liberalization of agricultural regulations in developing countries (e.g., Brazil) opened new markets (e.g. Middle East, North Africa), which increased demand for newly tradable agricultural products. Nowadays, Cargill operates in most countries, followed by Louis Dreyfus, Bunge, and ADM (Oxfam Research Reports , 2013).

As explained previously, globalization also meant the ABCD could legitimately expand its operations to all continents through land grabbing in Asia, Western Africa and Latin America. The 2008 food crisis exaggerated land grabbing globally, allowing corporations to systematically bypass the international trade of water, by obtaining water in a land form

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(Sojamo & et al, 2012). Evidently, 68 percent of the flow of agricultural and industrial VW trade products are recognized to be green water (e.g., precipitation) (Arjen Y. Hoekstra, 2011);

Cargill, the largest agricultural commodity trader in the world, purchased 52,576 hectares of Colombian land through 36 shell companies, escaping legal restrictions through fragmented purchases and surpassing Colombian land size permits per owner by more than 30 times (Oxfam Research Reports , 2013). Similarly, between 2005 and 2009, Louis Dreyfus (through subsidiaries Calyx Agro and Louis Dreyfus Company) acquired approximately 70,000 hectares of land in Argentina, Brazil, Paraguay and Uruguay, mainly devoted to food crops and cattle ranching, occasionally combined with nature conservation projects as a means of defeating deforestation and land use resistance (Oxfam Research Reports , 2013). However, not all acquisitions were directly engaged by the companies, as some was attained through various channels and entities, yet remained private in nature:

INVESTOR TYPE	AFRICA	AMERICAS	ASIA	EUROPE	OCEANIA
	AREA IN 1 000 HECTARES				
Private company	4 571	2 139	1 247	2 224	1 907
Stock exchange-listed company	1 683	1 334	3 152	2 257	60
Investment fund	1 254	809	6	452	0
State-owned entity	422	190	277	36	0
Individual entrepreneur	223	314	6	106	0
Other	67	0	0	7	0
No information	2 332	31	522	55	263

Table 2. Land acquisitions by investor type and target region (Oxfam Research Reports , 2013).

water consumption patterns, and their legality remain undisclosed under private firm policies (Oxfam Research Reports , 2013). The existing data over market share and non-location-specific aggregate operations data make it difficult to assess corporate water footprints and their corresponding power accurately. Because consumption habits remain hidden from end-consumers, individuals are often unaware of the explicit power of corporations within their value chains (Garcia-Ramon, 2019).

However, by multiplying the associated international crop trade volumes by their associated VW content (Hoekstra & Chapagain, 2006), one can make a strong assumption about water-power relations between corporations, states, and investment entities. Based on their global infrastructural capacity, from sourcing to storage and processing, to ports and transport fleet, their VW flows exhibit their substantial power (Sojamo & et al, 2012). The existing VW flow gap between eastern and western agricultural stakeholders emphasizes their hegemony as major global water managers (Sojamo & et al, 2012).

Contrary to the power corporations possess, they explicitly avoid assuming their natural role as water managers, becoming surprising yet vocal, supporters of the HRW (Sultana & Loftus, 2015). Based on discourse analysis of senior executives of water supply service firms and high-profile cancellations of water supply concession contracts (e.g., Manila, Buenos Aires,

 ISBN: 978-86-87043-85-5

Atlanta), corporations evidently retreated from earlier commitments to pursue private sector participation globally when faced with its regional risks and low profits in supplying the poor (Robbins, 2003). Sustainable policies make it harder to conduct business and maintain market competition; thus, they're unlikely to be sustainably implemented by private firms as well as public ones. Public companies, like Nestlé, who face severe criticism by direct consumers, investors, and advocacy groups were forced to seek remedial measures and WM development (Sojamo & Larson, 2012).

Sustainable policies development, the Water Resources Group, the WASH pledge, and commitments towards Transnational Water Stewardship, are but a few measures Nestlé and other transitional companies undertook to demonstrate cooperative water management (Vousvouras, 2016). Corporate Social Responsibility (CSR) has also been aggressively engaged to counter their environmental effects, yet it is recognized promotional in nature rather than emerging water governance (Sojamo & Larson, 2012). Although these measures are perceived as a form of corporates leadership, they're mostly enacted to guarantee sufficient production, reduce reputational damage, and gain legitimacy and critical consumers' support (Waldman & Kerr, 2014; Vos & Boelens, 2014). Water Stewardship endows corporations with power to shape practices and norms (Vos & Hinojosa, 2016), and it maintains hidden power dressed up in honorable and humane declarations. A final point to consider is that in all these initiatives is the low transparency and democracy in formulating standards and monitoring procedures, which are set by dominant market players who own the negotiating table (Amekawa, 2009; Campbell, 2005).

Conclusion

It is now evident that grasping the reality of power-oriented management of water trumps its idealistic aspiration as manifested in the HRW. Flyvbjerg's comparison of the realpolitik versus the idealist calls to cease the infatuation with an idealistic future. Instead, he calls us to face, however grim and prodigious as it may be, the power that creates, reproduces and reinforces the prevailed interpretation of reality. Flyvbjerg offers various propositions that proved extremely useful in identifying the methods by which corporations exercise their power. Foucault's emphasis on the relations of power, knowledge, and conflict, as means of exercising freedom demands the reality of water to be fully exposed. Habermasian notions risks moving away from the locus of the crisis to meaningless discussion that deepen corporate supremacy. Thus, the HRW must be soberly viewed not for its desired ambitions, but for its manifestation in reality; being ethical grounding, a notable milestone and a symbolism of justice, yet not a solution to WM.

Only through concretely identifying the full extent of reality and acting accordingly, could the water predicament progress into regulative substantial discussions. Thus, it is incumbent on international organizations, particularly the UN family, to recognize the unavoidable role of corporate interests as participants in water management. Water, like energy, food, trade, and so much else, is now globalized as a commodity and subject to the pressures of supply and

demand. What Flyvbjerg demonstrated is that the failure to incorporate all the stakeholders – and recognize the reality of the power that they wield – leads to a fundamental failure to recognize the dynamics at play in order to change these.

For water to be effectively managed globally, the clarion call of 'rights-based' policymaking will ultimately founder on the rocks of realpolitik. The idealist rights-based approach and the reality of the corporate-dominated neoliberal/commodification approach, are effectively talking passed one another. This failure of Habermasian discourse ethics (that all affected by a decision should participate in the making of a decision) is ultimately as much a responsibility of the rights-based advocates as it is of the self-interest of corporations. We have, in effect, two parallel systems effectively attempting to create policy and practice around the same issue. Aside from the somewhat incongruent support of the Right to Water by corporate interests, there is, effectively, a subdivision within the non-corporate rights-based approach: those advocating for a policy that accounts for some of the reality of corporate involvement; and a second segment that is wholly antithetical to any corporatization, privatization, or commodification, of water and water management.

However, beyond recognizing corporate power, the question remains: could it be harnessed to resolve the water predicament?. The methods by which their power is exercised could be reversed and channeled towards a shared water leadership. Cementing their power under a regulative title inherently binds it to global accountability and common WM end goals. Their emerging water governance (stewardship, CEO mandate, CSR), as well as its appeasing support to the HRW, is understood as a promotional façade that diverts from and conceals their power. Thus, mere regulatory oversight, bereft of direct consequences for corporate interests, is unlikely to provide sufficient leverage to ensure that private interests comply with the broader aims of good water governance. Regulatory oversight should be more integrated into consequential aspects of water management for communities. A far more viable scenario is the direct link between results and outcomes, with continued permission to operate in the market concerned. As such, licensing operations by corporations, based on key performance indicators linked directly to broader community-based goals, is necessary to ensure the proper functioning of the water market.

This does not mean that they alone would control water. The literature recognizers their inability to institute such leadership independently. It does however ensure that their power will be respectably acknowledged, titled, and harnessed, under global scrutiny; further limiting their capacity to exercise hidden power. Their financial capacity and economic motives might suggest that corporations are the most likely actor to invest, produce and utilizes technologies that could determine water scarcity and availability.

Given the explored nature of corporate power and its advertised calls to enshrine but only 1.5 percent of water under the HRW, one must acknowledge the probable truth that the future of water is already being formed behind closed doors. Capitalizing upon the fact that water became an unignorable business risk, other agents are encouraged to realize the primacy and urgency of exercising their power as a coherent force over the corporate dominion. As such,

 ISBN: 978-86-87043-85-5

this paper seeks to face the existing forces of the predicament and its arising approaches, in the hope of inspiring all humans essentially to exercise their given freedom and challenge the current water paradigm. Lastly, one could argue that the decision to either reject or accept the fallacy of water is the ultimate, and perhaps the only, possible action of power within the water crisis.

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Waste to energy (WtE) from infectious medical waste and organic Rankine cycle

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Abstract

This paper presents a simulation to determine the enhancement efficiency of an infectious medical waste treatment plant process based on the organic Rankine cycle (ORC). A treatment plant utilizing the steam sterilization process can be operated at 375 kg/cycle, with an operation cycle time of 55 min. The refrigerant fluid R-245fa generates the power in the ORC system. The system is driven by refuse-derived fuel type 3 (RDF-3). RDF-3 is produced from medical infectious waste at a low heating value of 26.92 MJ/kg. This is the main heat source for the hot water in the boiler of the ORC system. Infectious medical wastes are sterilized by using shredding and heating processes. The power consumption power of the machine is 23.24 kWh per operation day. The optimal systematic is evaluated by using the energy efficiency. The temperature of the hot water entering a boiler is found to vary in the range of 80-125 °C. From the simulation, the average energy efficiency of the ORC system is determined to be approximately 10.37%. The gross electricity power output in the expander varies in the range of 16.04-112.73 kW. The total average power output is approximately 413.82 kW.

Keywords: Waste to energy (WtE); infectious medical waste; organic Rankine cycle; refuse-derived fuel

1. Introduction

An issue arising from the coronavirus (COVID-19) pandemic is the collection and transport of infectious medical waste (IMW) to treatment centers. IMW remains a critical operational problem facing local authorities in all cities. The COVID-19 pandemic has led to the delivery of medical services for society all over the world. The COVID-19 pandemic is influencing waste management and especially medical waste management. According to the World Health Organization (W.H.O) [1], the total waste generated at hospitals is approximately 85% general waste and 15% hazardous material that can be toxic, infectious, or radioactive. The majority of infectious medical waste generators are laboratories, home isolations, mortuaries, blood banks, research centers, hospitals, and nursing homes. Medical waste contains potentially dangerous microorganisms. This waste may infect medical center patients, staff, the public, and the environment. Medical waste storage at health care centers and the transportation of these materials can be potentially harmful to

 ISBN: 978-86-87043-85-5

Nomenclature

Abbreviations and symbols

A	area, (m^2)
CHP	Combined heat and power
EP	electric power
ORC	organic Rankine cycle
P	pressure, (bar)
Q	heat rate, (kW)
RDF	refuse derived fuel
t	time, (s)
T	temperature, (°C)
W	work, (kW)

Subscript

A	absorber
AB	absorption system
AP	absorber pump
Amb	ambient
apm	air pressure motor
B	boiler
BW	blower
C	condenser
CDP	cooling draining pump
CF	cooling fan
CP	cooling pump
CW	cooling water
CT	cooling tower
DP	Decompression pump
e	electrical power
E	evaporator
EH	Exhaust stack
Exp	expander
H	high
HB	hot air blower
HF	hot fluid
HFT	hot fluid tank
HP	hot water pump
HW	hot water
HDP	Hydraulic darning pump
HOP	Hydraulic open pump
HTP	Hydraulic top pump
HS	heat source
HUP	Hydraulic under pump
HW	hot water
i	inlet
m	motor
o	outlet
OP	oil pump
op	operation time
P	refrigerant pump
P	pump
Ref	refrigerant
WF	working fluid
S	isentropic
SP	solution pump

Greek

η	energy efficiency, (%)
ρ	density, (kg/m^3)

treatment centers. These results indicate that the COVID-19 epidemic has led to an increase in waste generation of 102.2% on average in both private and public hospitals. In addition, the ratio of infectious waste in study hospitals has increased by an average of 9% in medical waste composition and 121% compared with that before the COVID-19 pandemic. Therefore, the disposal of infectious medical waste is a problem for all counties in the world. Therefore, this study aims to identify waste-to-energy solutions to solve this problem.

Waste-to-energy technology and collection transportation have been reported by various researchers. Nikzamir et al. [2] reported that waste management was a location-routing problem with the water-flow algorithm. Foroushani et al. [3] found that data waste management for energy drives the modeling of operational district energy networks. This showed that hourly thermal energy storage in a water tank can reduce the daily peak loads on boilers by as much as 20%. Taslimi et al. [4] considered transportation and storage risk with a decomposition-based heuristic. The model showed that Transport Risk & Occupational Risk has a risk value of 110.92 for a run

time of 5 min 12 s and the transportation cost has risk value of 150.12 for a run time of 5 min 17 s. Valizadeh et al. [5] showed that energy can be produced from waste during the COVID-19 pandemic, and 34% of the total cost of collecting and transporting waste can be compensated. Govindan et al. [6] used a fuzzy mathematical programming model for medical waste management. The goal of the program was to approach the COVID-19 disease to determine the routing minimum cost and optimize the collection of infectious waste. Yatsunthea et al. [7] studied the energy process for municipal wastes based on the organic Rankine cycle. An incinerator system was used as a heat source from infectious medical waste mixed with municipal waste. A low heating value of 26.92 MJ/kg was obtained. The mixed fuel showed a disposal rate of approximately 92 kg/h. The energy efficiency was 31.66%, and the exergy efficiency was 4.05%. The ORC used an R-245fa-ORC refrigerant system to produce electricity at a gross power of 23.65 kW. Fredy Vélez et al. [8] reviewed the technical, economic, and market issues for organic Rankine cycles for the conversion of low-grade heat. At present, power generation is limited mainly to the range of 0.2-2 MWe with a cost of approximately 1 and 4×10^3 USD/kWe. Chaiyat [9] studied and analyzed the energy, economic, environmental (3E), and exergy (4E) impacts of infectious medical waste incinerators combined with an organic Rankine cycle. The ORC system used R-245fa as a working fluid to investigate the overall impacts. The system could manage a refuse-derived fuel type 3 (RDF-3) at 184.42 kg/h from infectious medical waste to produce 23.65 kWe. The power at energy efficiency was 0.91%, and the exergy efficiency was approximately 0.89%. The economic levelized energy cost was 0.153 USD/kWh. Intaniwet et al. [10] studied the levelized electricity cost per carbon dioxide intensity of an organic Rankine cycle. Water hyacinth and municipal solid waste were used at a ratio of 50:50%. Their heat source produced 20 kWe. The organic Rankine cycle has been evaluated in terms of energy, economic and environmental aspects (3E model). The levelized electricity cost from a water hyacinth-MSW-ORC (WMORC) system was determined to be 0.086 USD/kWh. The environmental impact, 0.172 kg CO_2-eq of greenhouse gas emissions, was estimated based on the utilization of 1 kg of the new fuel. The life cycle assessment for the WMORC system was 0.6078 kg CO_2-eq for an electrical energy generation of 1 kWh. The levelized electricity cost per carbon dioxide intensity was defined and found to be 0.052 USD·kg CO_2-eq/kWh^2, which is 20% lower compared to the value of 0.065 USD·kg CO_2-eq/kWh^2 obtained from a standard power plant in Thailand. Sengnavong et al. [11] studied the cost evaluation for medical infectious waste treatment and found a cost per unit of 0.099 USD/kW_{MCW}.

A literature review shows that many studies have reported collecting data on infectious waste and waste-to-energy technology, such as incinerators and bioenergy. A demonstrated prototype has not been presented; in particular, techniques to manage the volume transportation of infectious medical waste have not been reported. How much is the capacity of the treatment center? Many infectious medical wastes for the generation of electricity have not been reported in the recent literature. In particular, there has been no study of the transportation of volume infectious medical waste with software management. An interesting approach is novel design process management transportation of volume infectious medical waste appropriate for the organic Rankine cycle (ORC) and incinerator from a fuel composed of infectious medical waste. Through a combined heat and power (CHP) system. The experimental results of the advanced system are obtained to evaluate the gross electrical performance curves. This study aims to

1. Design the transportation process for a volume of infectious medical waste appropriate for the treatment process.

2. Simulate the heat capacity in an incinerator, with the produced gross power giving the energy efficiency of the ORC system.

2. System description

In this study, medical infectious wastes are treated by hybrid steaming sterilization. After the treatment process, medical infectious waste becomes refuel-derived fuel type-3 (RDF-3). They are the initial heat source appropriate for the incinerator investigated. A schematic diagram of the treatment process and CHP system is shown in Fig. 1. Infectious medical wastes are placed into treatment machines. The machine shreds and sterilizes infectious waste to reduce its volume. Then, all components are rendered unrecognizable in one fully enclosed chamber. The machine is an automated system. It combines shredding, direct steam sterilization, and high pressure to treat infectious waste materials. The processes use gravity. After shredding the material, it is dropped into a lower treatment chamber. Each particle is steam heated to 138 °C (280 F). The mixture is pressurized to 3-5 bar (51 psi) for 10 minutes. The operating and treatment conditions are continuously monitored and validated to achieve complete sterilization (microbial inactivation = 108 °C). After the cooling process, the final product is volume-reduced by up to 80%. The waste rendered unrecognizable is general waste and safe to recycle. This waste is used as a heat source for generating power in the ORC system. The duration of an average cycle process is 45 minutes, and is fully automated and monitored. The process generating the power system is shown in the side figure. Three main systems are combined to produce waste to energy: a hot fluid storage tank, incinerator, and ORC system. In the first point system, point R1, the appropriate value of RDF-3_{Dry}, is the initial heat source for combustion. This is selected for solid fuel transformation. In the second incinerator system, solid fuels are fed through a small chimney at the front side of the combustion chamber. Solid wastes RDF-3 are used as the combustion substrate. Then, heat is generated at (points 1–3 h). The storage tank is used to collect the heated fluid to supply the purified liquid fluid to the power unit. The combustion gas (exhaust) moves through the treatment unit. A hot air blower is used to force the exhaust gas into a double-absorber working set, in which all particulates and pollution are reduced by an absorption filter technique from spray water nozzles. These air pollutants are controlled under the standards set by the Pollution Control Department, Thailand [12]. Then, the reheat tube, cooling set, and vacuum filter are finally treated with the dioxin compound of dibenzofurans (PCDF) and polychlorinated dibenzo-p-dioxins (PCDD). Next, all clean gas is circulated into the environment by using the main exhaust stack. However, the bypass exhaust stack can be switched into operation in case of service and maintenance. The output products in the bottom ash are rejected below the combustion chamber.

The second system: the ORC system is used for heat-to-power technology. The hot fluids (points 4 h - 6 h) are pumped from the storage tank into the power unit (points 1–7). The ORC working fluid in the liquid phase is pumped to transfer heat to the ORC boiler. A dry type or an isentropic type of refrigerant is popular for use in a refrigerant loop (points 1–4 and 7). The superheated vapor is intently generated from the boiler component to efficiently drive the expander during the heat to thermal power process. Lubricant oil loops (points 4–6) are designed to reduce the friction loss in the reversed expander. Therefore, the refrigerant and lubricant oil are mixed in the expander and sent out to separate the mixed fluid at the oil and separator tank. The generator is situated in the work-to-power component that is mechanically connected to the expander. Then, the refrigerant at the vapor phase is divided from the oil and vapor separator and flows into the condenser. Heat is extracted from this working fluid and condensed by using a cooling loop (points

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1c-3c), which is driven by the cooling pump and cooling tower. Next, the condensed working fluids are pumped to the boiler again, and a new ORC cycle starts.

The energy efficiency indicators for the incinerator, ORC, and cycles are determined as follows:

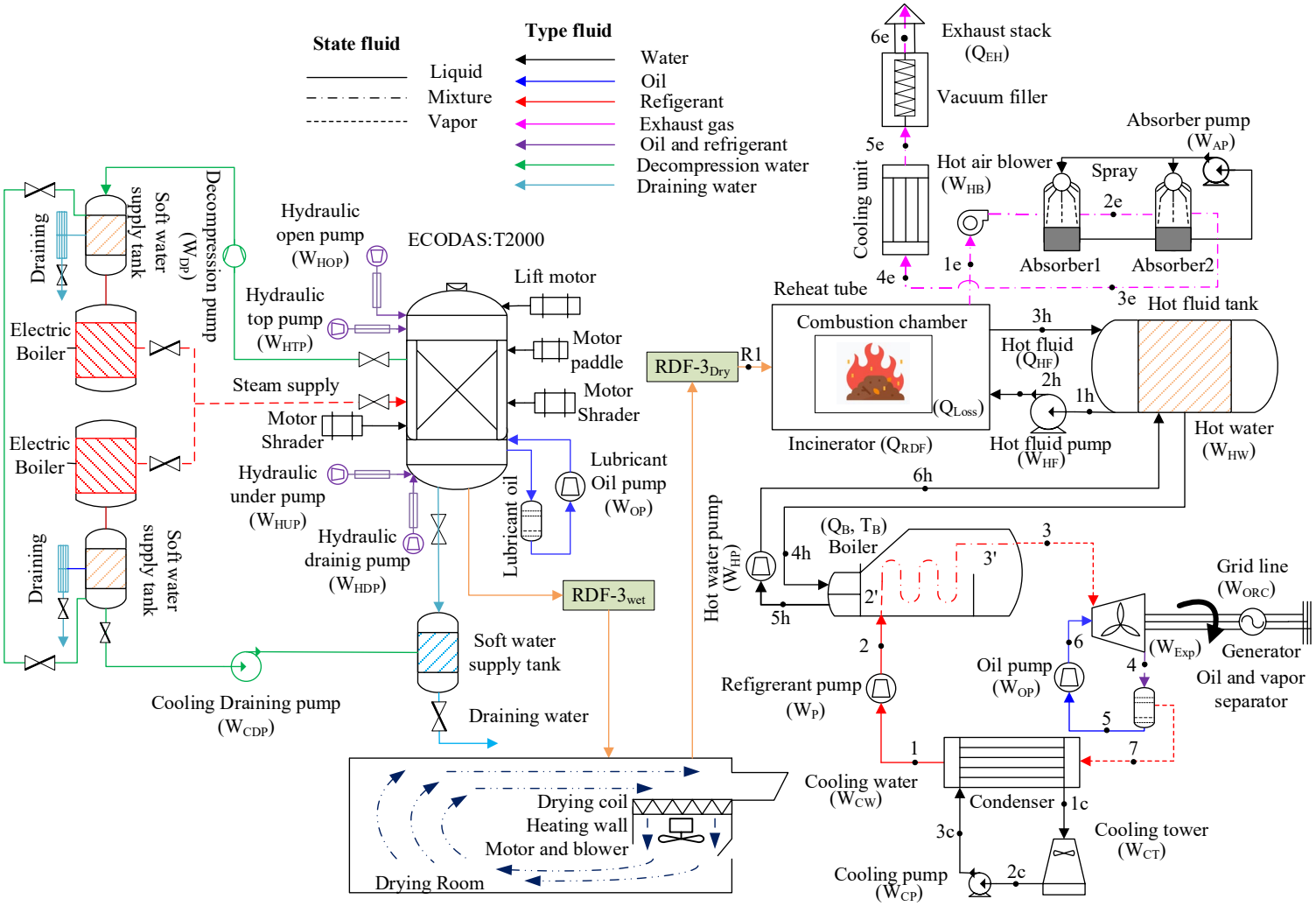

Fig. 1. Infectious medical waste treatment and Organic Rankine Cycle system.

3. Materials and Methods

The schematic shows how one can determine the volume of RDF-3 that is appropriate for the heat source for a suitable efficiency model of incinerator and power output ORC systems.

3.1 Mathematical modeling of the incinerator and ORC system

Mathematical modeling of the incinerator and the ORC system is used to analyze the volume of RDF-3 appropriate for the incinerator and ORC performance. The properties of the working fluid are referred to from the Refprop program [13]. The simulation steps for energy and efficiency are shown in Fig. 2. The given initial conditions for the system are as follows:

These mathematical models are solution process simulations to determine the waste-to-power performance and the efficiency of the treatment plant for the infectious medical waste process, incinerator, and ORC system. The next idea is to use these data to design and build a small power plant with medical infectious waste as the heat source.

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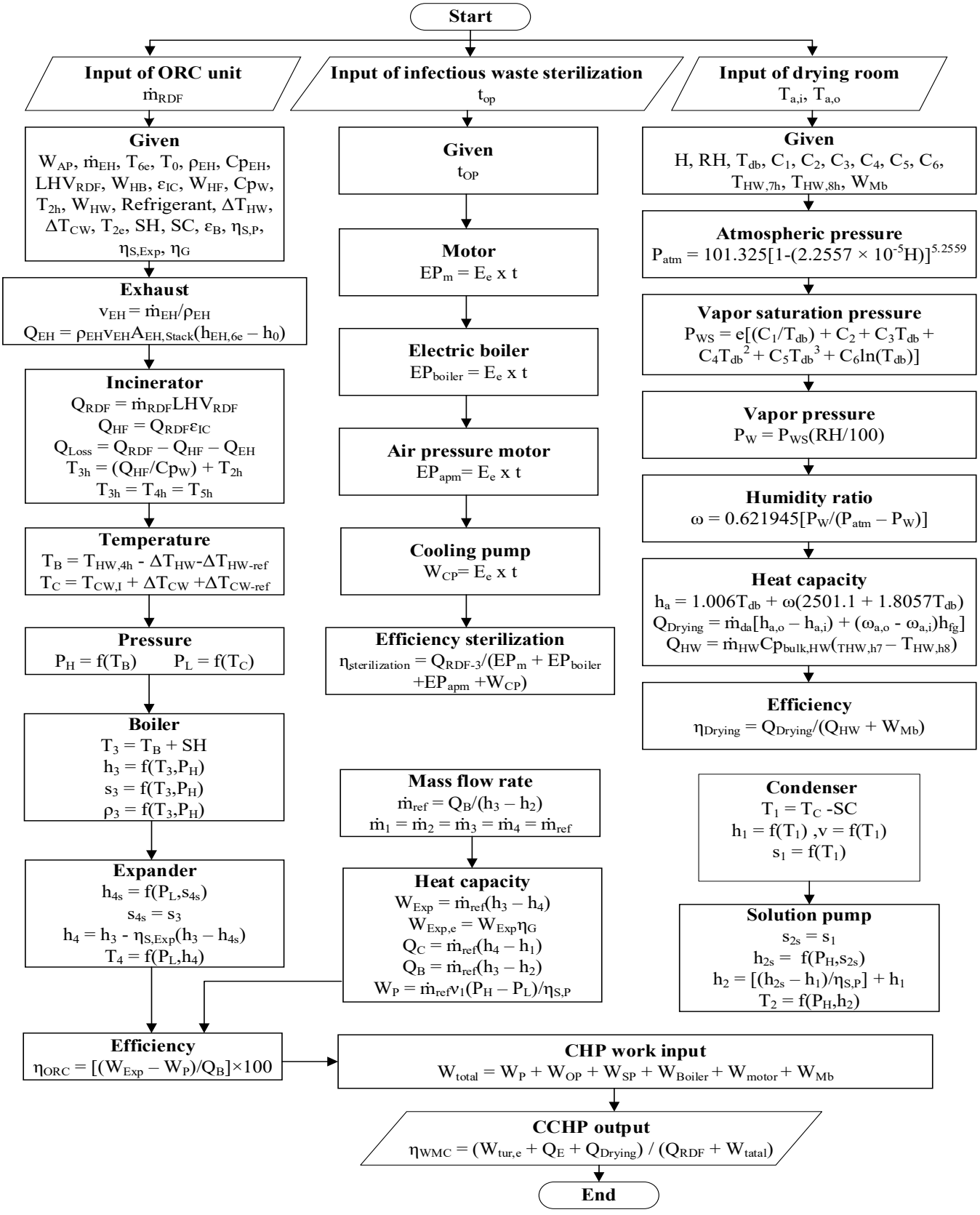

Fig. 2. Waste management center, incinerator, and ORC performance

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4. Results and discussion

4.1 Thermal performance analysis of the ORC system

Fig. 3 shows the heat capacity in the incinerator at the combustion solid waste feed rate ($\dot{m}_{RDF}$) of 300-750 kg/h. The calculated results show that the RDF-3 heat capacity rate (Q_{RDF}) is 2,243.33-5,608.33 kW. The transformation system of solid fuels is processing. The heat of the hot fluid can produce a thermal capacity rate (Q_{HF}) of 1,906.43-4,767.08 kW. As the process continues, the heat capacity loss (Q_{Loss}) in the system is 203.84-708.59 kW. The data obtained for the heating capacity rate and thermal capacity rate are increasingly influenced by the effect of the combustion rate.

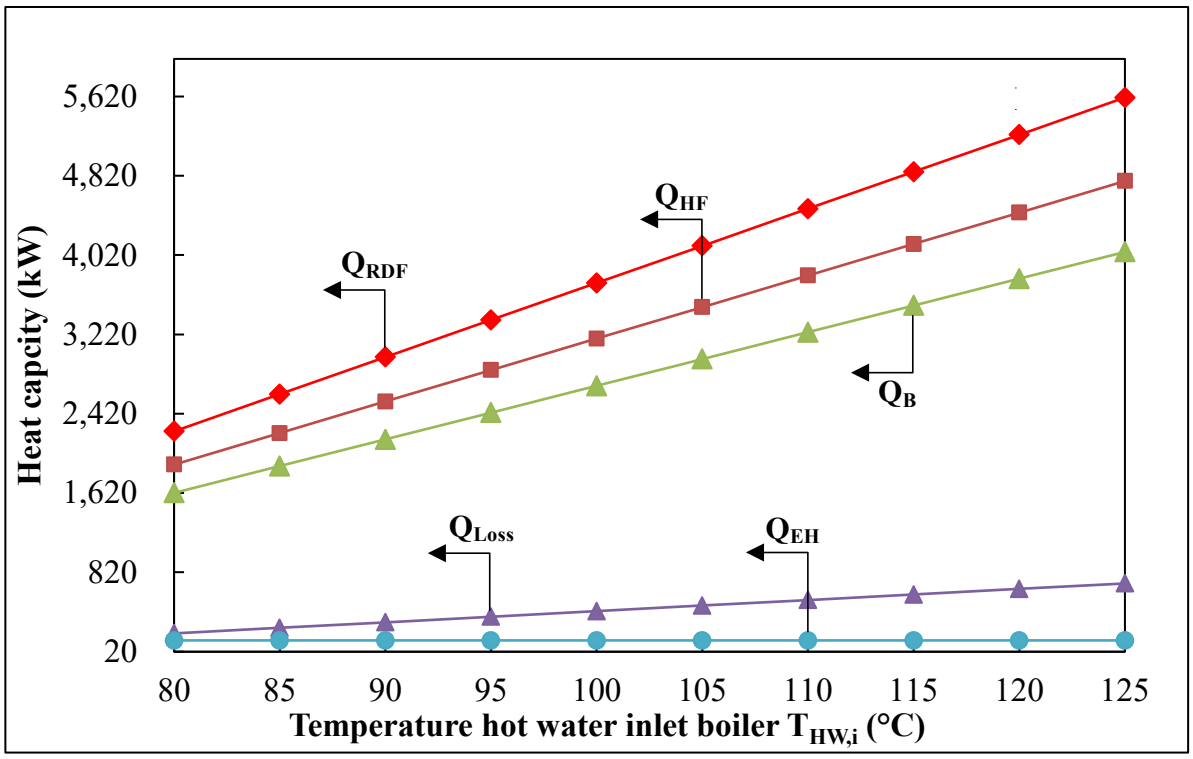

Fig. 1. Heat capacity of the incinerator and ORC system.

Fig. 4. Consider an ORC system with a thermal power output in the range of 97.40-413.82 kW. Therefore, for a boiler with a hot water inlet, the fluid is very hot. The heat of the boiler closely follows that shown in Fig. 5.

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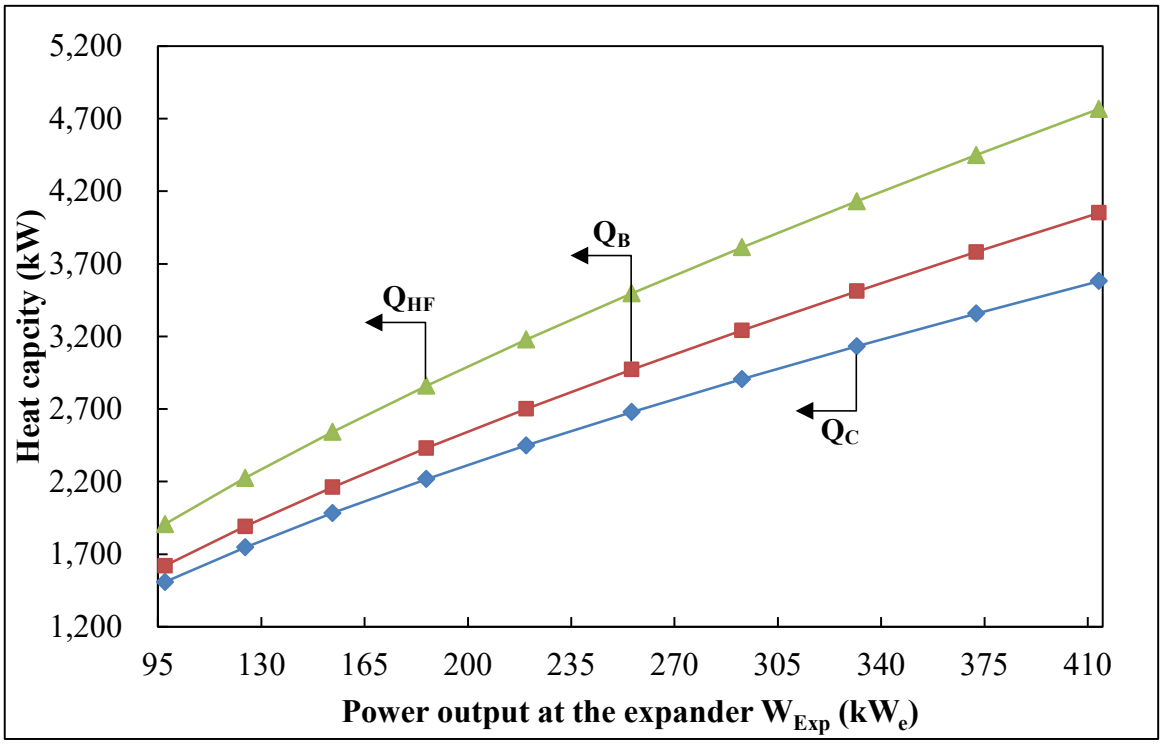

Fig. 2. Heat capacity of the hot water, boiler, and condenser in the ORC system.

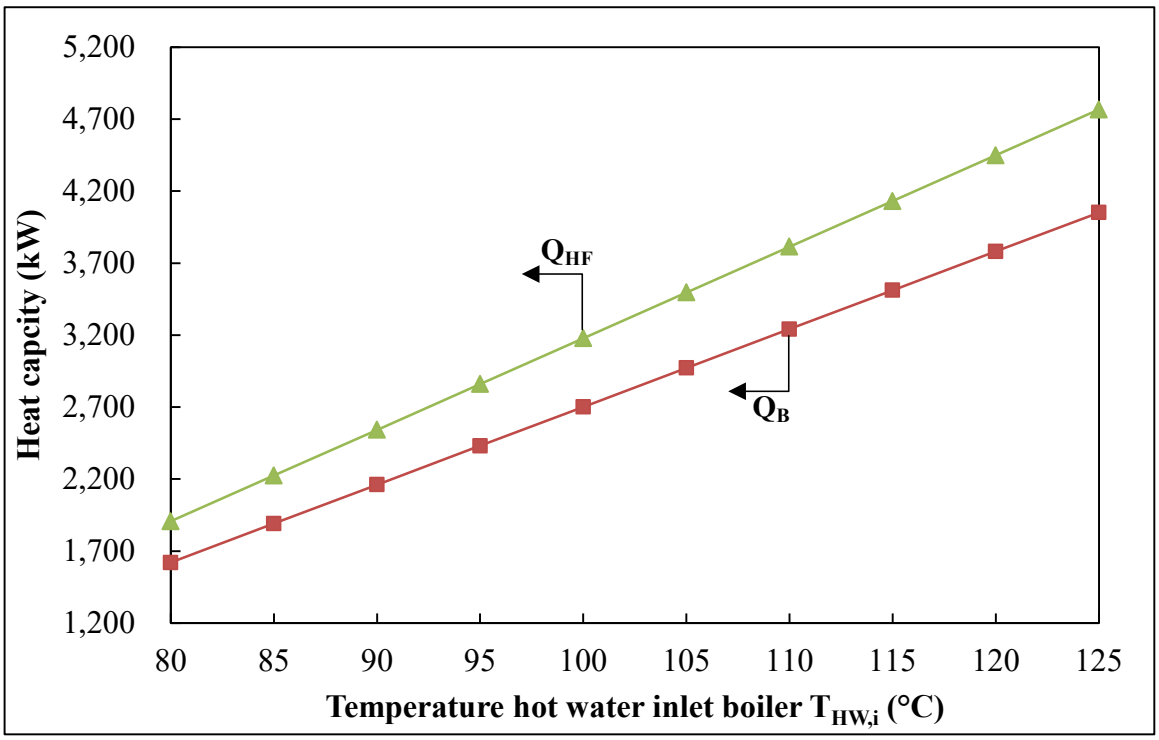

Fig. 3. Heat capacity of a hot water inlet boiler and the heat capacity at the boiler.

Fig. 6. shows that the working fluid temperature impacts the power output of the ORC and is slightly higher. The output work refrigerant pump feed-in boiler has a range of 0.26-3.14 kW. Furthermore, the working fluid temperatures leave the expender (T_4). This point fluid temperature

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is revealed to range from 56.63-117 °C. Then, the temperature point that is output from the boiler (T_3) is considered. If the temperature to the thigh is impacted, the gross power expander output is also impacted. The focused heat capacity of the boiler, condenser, and input heat is the working fluid. The heat of the boiler also closely follows the temperature as the working fluid is heated. The condenser heat leaving the expander decreases. This follows with working is refrigerant. The mass flow rate ($\dot{m}_{ref}$) in the system ranges from1.23-2.86 kg/s.

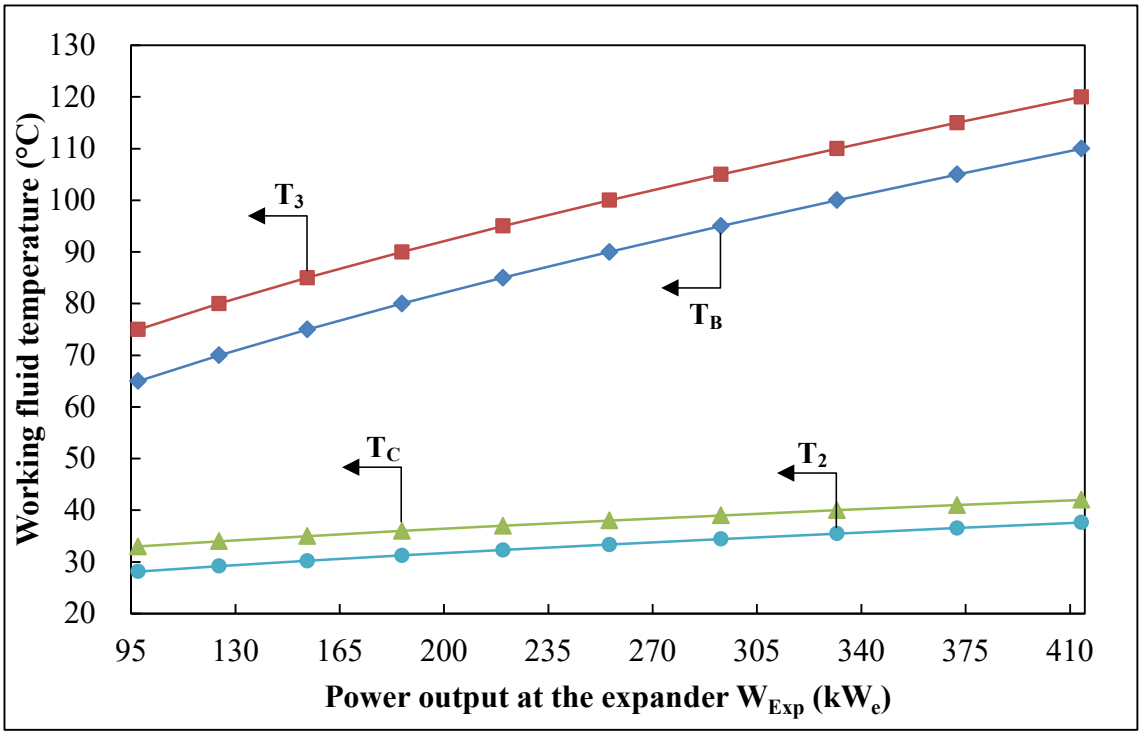

Fig. 4. Working fluid temperature in the ORC system.

Fig. 7. Furthermore, the working fluid temperature leaves the expender, which shows the effect of hot water entering the boiler. The operating temperature ranges from 80-125 °C. The ORC energy efficiencies and the heat input at the boiler for the case of the energy impact are very high. The increase in the power output of the turbine for electricity generation can be approximately 16.04-112.73 kW. The final results show that the energy efficiency is increased. The influence of the effect of the hot water temperature at the rage inlet boiler rung is 5.85-14.44%, as shown in Fig. 8.

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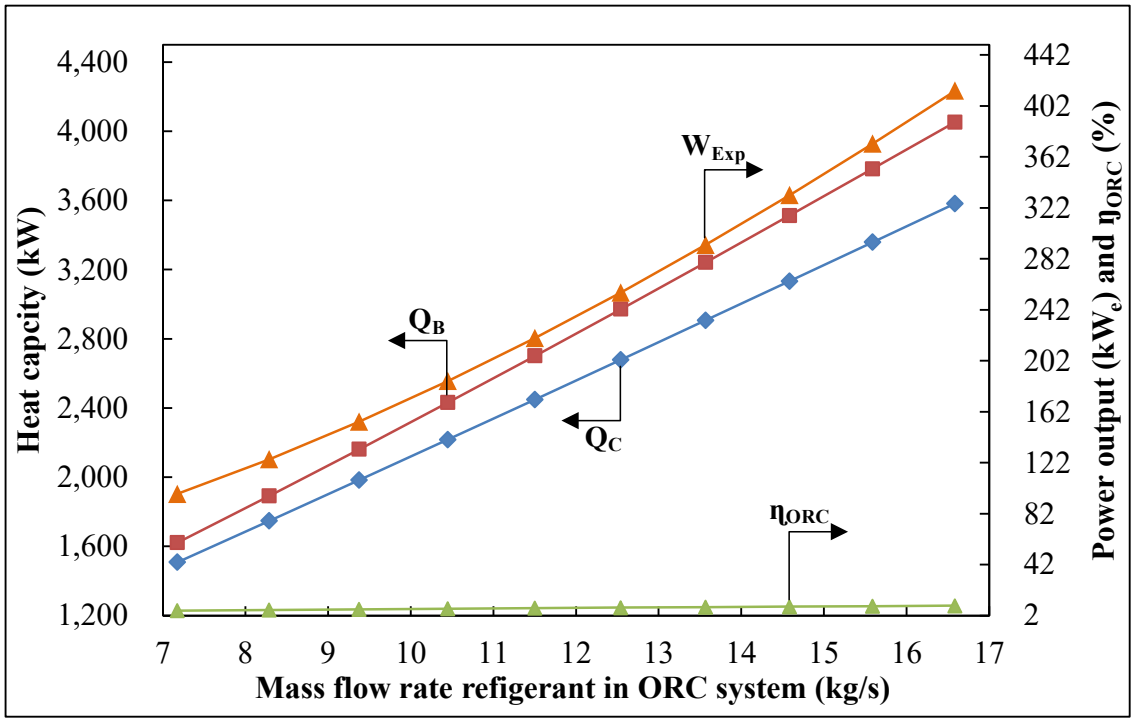

Fig. 5. The power output at the expander in heat capacity impact.

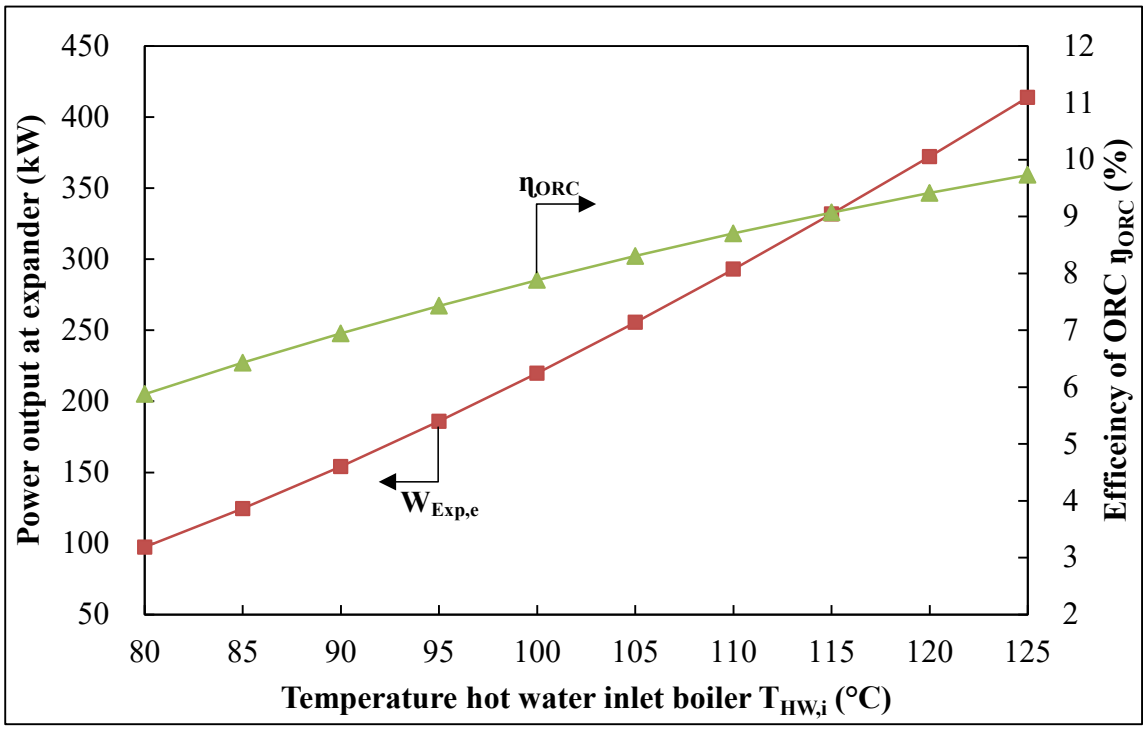

Fig. 6. Energy efficiency of the ORC system.

Fig. 9. A comparison of the input power for process sterilization and the consumption of power during operation. The system are operating operates in the range of 23.24-176.24 kWh.

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The resulting power output in the expander system of the ORC ranges from 97.40-413.82 kW. The result shows that a high-value output efficiency is obtained during system operation and is worth investing in.

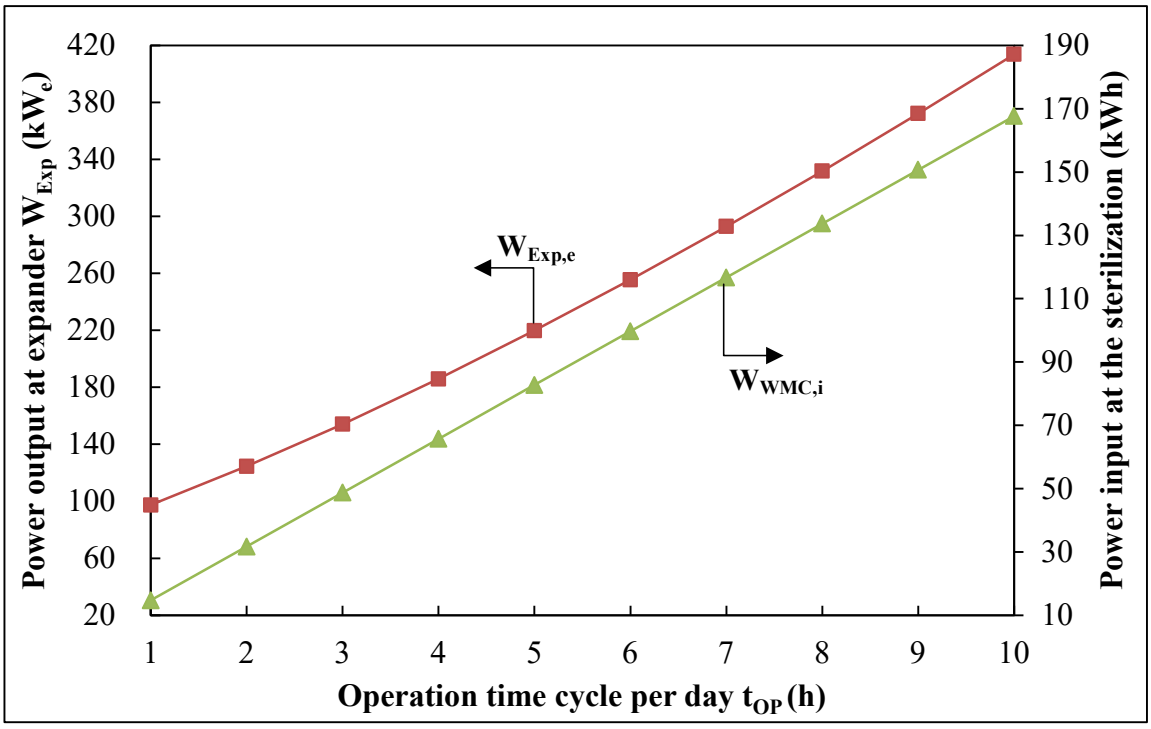

Fig. 7. Comparison of the input power for sterilization and the power output of the ORC

5. Conclusions

The conclusion from the schematics is that the use of RDF-3 is appropriate. The process for generating gross electric power output for an ORC system can be concluded as follows:

- The simulation results show a heat capacity at the incinerator combustion chamber RDF-3 (Q_{RDF}) in the range of 3,738.89-3,741.88 kW. The heat capacity of the hot water fluid (Q_{HF}) ranges from 317.09-892.70 kW. The heat capacity of the boiler (Q_B) ranges from 269.53-58.80 kW. The heat capacity at the condenser (Q_C) system varies in the range of 250.97-629.41 kW.
- The temperature in the ORC system is impacted by the heat capacity. The working fluid temperature follows the temperature at the boiler inlet (T_2) in the range of 35.13-35.60 °C. The boiler temperature (T_B) varies in the range of 62-107 °C. The temperature at the boiler output is superheated (T_3) in the range of 72-117 °C. The temperature of the leaf expander (T_4) ranges from 56.63 °C-71.75 °C. The temperature of the condenser (T_C) is stable at 40 °C.
- The work of the refrigerant pump is fed into the boiler (W_P) in the range of 0.26-3.14 kW.
- The gross electricity power output in the expander varies in the range of 16.04-12.73 kW.
- The average power output is 58.9 kW. The energy efficiency of the ORC system output varies in the range of 5.85-14.44%.

Acknowledgment

The author would like to thank the School of Renewable Energy, Maejo University for the project to produce and develop graduates in renewable energy ASEAN countries for graduate students (2021) and for supporting testing facilities and research budget.

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