

RESEARCH ARTICLE

Biodiversity, Planning and Development – Towards Best Practice

Amazonia 2040: Spatial-explicit futures scenarios for the mosaic of protected areas in the Lower Rio Negro (MBRN), Brazil

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Abstract

1. Amazonia faces a socio-environmental emergency driven by anthropogenic activities, leading to biodiversity loss and decay of ecosystem services. To address these effects, Brazilian initiatives have established a large-scale conservation approach known as the mosaics of protected areas (PAs), which fosters collaborative governance for conservation action. Practitioners face constant pressures from human activities and have historically endured intentional dismantling of governance, forcing the local leaders to become reactive and short-sighted. Long-term thinking can help governance anticipate change and better prepare for alternative futures.
2. We applied an innovative approach to futures workshops with the Council of Leaders of the Mosaic of Protected Areas of the Lower Rio Negro (MBRN), and the Federal University of Amazonas (UFAM). Participants co-created scenarios for the MBRN in 2040, negotiating desirable futures and aligning values and goals. The workshops were co-designed with stakeholders, incorporating futures literacy, leadership empowerment and spatial knowledge; building on a novel approach called spatial-explicit futures scenarios (SEFS).
3. *Probable scenarios* co-created in these workshops describe futures where local citizens have little agency in decision-making, depicting environmental decay, economic instability and high levels of corruption. In resistance, local associations strengthen through voluntary work and fight for the resilience of local governance despite the lack of resources.
4. *Desirable scenarios* point towards an ecologically respectful and sustainable MBRN, with effective governance of resources. In these scenarios, communities' interests are legitimately represented and play a fundamental role in decision-making. Young adults are professionally qualified, have implemented sewage systems, clean energy and integrated communication networks. Community-based tourism and the carbon-offset market strengthen the economy and well-being.

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5. *Practical implication.* Improved preparedness of PAs managers and community leaders. Leadership processes are strengthened by anticipating challenges and co-creating actionable insights that make desired scenarios viable. Including historically silenced voices in territorial strategic planning opens up space for these groups to express their desires and aspirations and develop strategic plans. In doing so, SEFS promotes sustainable and just land-use planning. The proposed methodology contributes to decolonizing science and encourages inclusive, just and sustainable management. The method can be applied beyond Amazonia, enabling stakeholders to develop their own futures-thinking processes.

KEYWORDS

Amazonia, Futures Literacy Laboratories, Mosaic of Protected Areas of the Lower Rio Negro, participatory action research, Participatory Geographical Information System, protected areas management, scenarios, stakeholder participation, workshop

1 | INTRODUCTION

Tropical forests are facing unprecedented threats from anthropogenic activities, such as deforestation, climate change and resource exploitation, putting both biodiversity and the livelihoods of traditional peoples at risk. Amazonia, the largest rainforest in the world, covers around 6.7 million km² and has gone through several cycles of exploitation, such as the rubber boom, mining, large-scale agriculture and cattle farming. Currently, the region faces an increasing human occupation and forest degradation leading to a socioecological emergency (Amigo, 2020; Nepstad et al., 2008; Nobre & Borma, 2009).

Economic development models are fuelling biodiversity loss, leading to devastating and irreversible change (Nobre, 2019; Nobre & Borma, 2009; Sirica, 2020). It is estimated that by 2019, 18% of the forest had been substituted by agriculture, and of the remaining standing forest, 60% was significantly degraded (Dourojeanni, 2019). Even under these intensified pressures, protected areas (PAs) and indigenous areas have been effective barriers to deforestation and other predatory activities within their territorial constraint.

Protected areas, or conservation units (*unidades de conservação*) are defined in the Brazilian law as 'designated areas with significant natural features, established by the government to achieve conservation goals' (Brazilian Ministry of Education, 2011). These areas are managed under special administrative regimes with legal protections to ensure their preservation. The law encompasses Federal, State and Municipal units and outlines the objectives of the National System of Conservation Units (SNUC), that is, to maintain biodiversity, to protect endangered species, to restore ecosystems, to promote sustainable development and to support environmental education and research. It also emphasizes community involvement, sustainable use of resources and the integration of conservation efforts across various regions and ecosystems.

To remain effective, PAs management should include robust co-governance and stakeholder participation (Acosta et al., 2018). To foster large-scale and collaborative governance mechanisms for

conservation action, since 2010, the Brazilian government has established mosaics of PAs. The strategic plan includes 26 mosaics (Burgos & Mertens, 2022, p. 2).

These increasing pressures from human activities, the intentional dismantling of governance during the 2018–2022 presidential term and the COVID-19 pandemic have created a situation of immediate threats, demanding quick responses (Pineiro et al., 2022). In this context of instability, engaging in long-term governance planning and devoting resources to problems of the distant future is less likely (Dreyer & Stang, 2013, p. 16). Therefore, it becomes clear that in this context, conservation-oriented leaderships often lack resources for long-term thinking.

However, recent efforts for futures thinking in Amazonia have taken momentum, as the Amazon Fund was re-established, a new Ministry for Indigenous Affairs was created, and several calls were opened for funding conservation action projects (ECPA, 2023). This presents a good opportunity to develop long-term plans that can benefit from strategic foresight methods.

Exploring futures scenarios requires looking at the present from different perspectives, and often deliberately breaking from traditional thinking (Bell, 2003). Scenarios are representations of possible futures in the form of narratives that can be desirable or undesirable, probable or unlikely. These narratives about possible futures have the power to guide decision-making processes, revealing perceived threats, available opportunities, hopes and fears. Various types of scenarios can be developed for different purposes (Dator, 2019; Miller, 2018).

In this study, we address futures thinking in the context of a large area in Central Amazonia of 80,000 km². We ask the question: *What kind of futures do people working for PAs in the Lower Rio Negro imagine for the region?*

We address managers of these PAs, NGOs working in socio-biodiversity, government officials, community leaders, grassroots organizations, business people, as well as scholars specialized in the region. To optimize time and logistics, we collected data in two workshops at different locations: Manaus and Novo Airão. The first

workshop, held in Manaus at the Federal University of Amazonas (UFAM), focused mainly on the academic community. The second, held in Novo Airão, in the premises of the Vitoria Amazonica Foundation (FVA), focused on practitioners, members of the council of the Mosaic of Protected Areas of the Lower Rio Negro (MBRN) ([Supporting Information: Annex 1](#)).

Building on foundations of Human Geography, Sociology, Futures Studies and Strategic Foresight, we applied a novel approach called spatial-explicit futures scenarios (SEFS) approach, which combines traditional futures workshops with participatory mapping. We applied SEFS to co-create scenarios of probable and desirable futures for 2040, focusing on leadership preparedness and identifying points of action towards the mapped desirable futures.

2 | MATERIALS AND METHODS

2.1 | Study Area

This study focuses on the MBRN. When it was created in 2010, it had an area of 80,000km² on the basin of the rivers Negro, Amazon, Jaú and Unini; in the State of Amazonas, North of Brazil, composed of 11 PAs all having the Negro River as a common resource (MMA, B, 2010). From 2010 to July 2023 (when fieldwork was conducted), another three areas were included in the council, even though these were awaiting to be officially recognized by the Ministry of the Environment. Between 2023 and 2025, two other areas were added to the council and were also awaiting official notification of inclusion. In this study, 14 areas recognized by the council at the time of conducting the workshops were included ([Figure 1](#)). It is estimated that around 100,000 inhabitants live in the PAs (Cardoso, 2010) divided into 273 communities (Alves & Pereira, 2023).

The region is a UNESCO world heritage site and is part of the Central Amazon Conservation Complex Biosphere Reserve (UNESCO, 2000). Rio Negro basin is one of the biodiversity richest areas and it includes Anavilhanas, the largest fluvial archipelago in the world (UNESCO, 2000). It has long faced threats from human activity and climate change, and increasingly also from the intentional and systematic dismantling of the local administrative powers by the state (Illenseer & Pereira, 2010; Pinheiro et al., 2022).

The PA in the MBRN are under heterogeneous regimes of protection and governance. They undergo various forms of land use and are managed by different organizations at the National, State and Municipal levels ([Supporting Information: Annex 1](#)). All council members have a 2-year mandate and are unpaid volunteers (Brazilian Ministry of Environment, 2010).

2.2 | Workshop participants

The study engaged a diverse group of stakeholders engaged in the management and governance of PAs in the Lower Rio Negro region. Participants included managers of conservation areas,

representatives from non-governmental organizations (NGOs) working with socio-biodiversity, government officials, community leaders, grassroots organizations, business representatives and scholars specialized in the region.

To optimize time and logistics, data were collected through two workshops held in different locations in the State of Amazonas, Brazil—Manaus and Novo Airão—during July 2023. The workshops were not specifically targeted at academic or practitioner audiences; they were open to individuals working in or collaborating with the PAs of the MBRN. However, due to the locations where the workshops were held, the composition of participants organically reflected the predominant institutional and socio-territorial profiles of each context.

The first workshop was held in Manaus, at the Federal University of Amazonas (UFAM) and brought together 41 participants, primarily from the academic community and organized civil society. An open invitation was widely disseminated through UFAM and the National Institute of Amazonian Research (INPA) institutional communication channels. Additionally, the coordination of the Postgraduate Program in Environmental Sciences and Sustainability (PPGCASA) actively promoted participation among faculty members and students, resulting in strong representation from the programme.

Regarding participants' institutional profiles, 20 were affiliated with UFAM, including faculty, doctoral researchers and graduate students from PPGCASA; six were researchers from INPA; and 15 represented organized civil society, including professionals from environmental management, engineering, sociology, humanities, geography, NGOs, tourism agencies and the private sector.

The registration process to this first workshop was conducted through the platform Even3 and was free of charge. Therefore, participant selection can be characterized as a voluntary, non-probabilistic and self-selection process, a procedure commonly used in participatory studies and collaborative methodologies. This process supported the formation of a heterogeneous group, enabling the integration of different professional, academic and institutional experiences, which was considered relevant for collective reflection within the workshop context.

The second workshop was held in Novo Airão, at the premises of the Vitória Amazônica Foundation (FVA), and gathered 23 participants. There, the participant mobilization strategy was conducted by the coordination of the MBRN council, which articulated institutional invitations within the context of the council's annual meeting held that year. Thus, all council members attending the annual meeting participated in the workshop activities, characterizing an intentional selection process based on prior institutional participation within the MBRN governance space.

Participants of this second workshop represented a cross-section of the MBRN council: representatives of Federal and State PAs, and of sustainable development reserves; municipal representatives from territories encompassing the conservation units, representatives of Indigenous communities from the region, and members of grassroots organizations and local businesses. It is noteworthy that not all council members are administrative or governmental

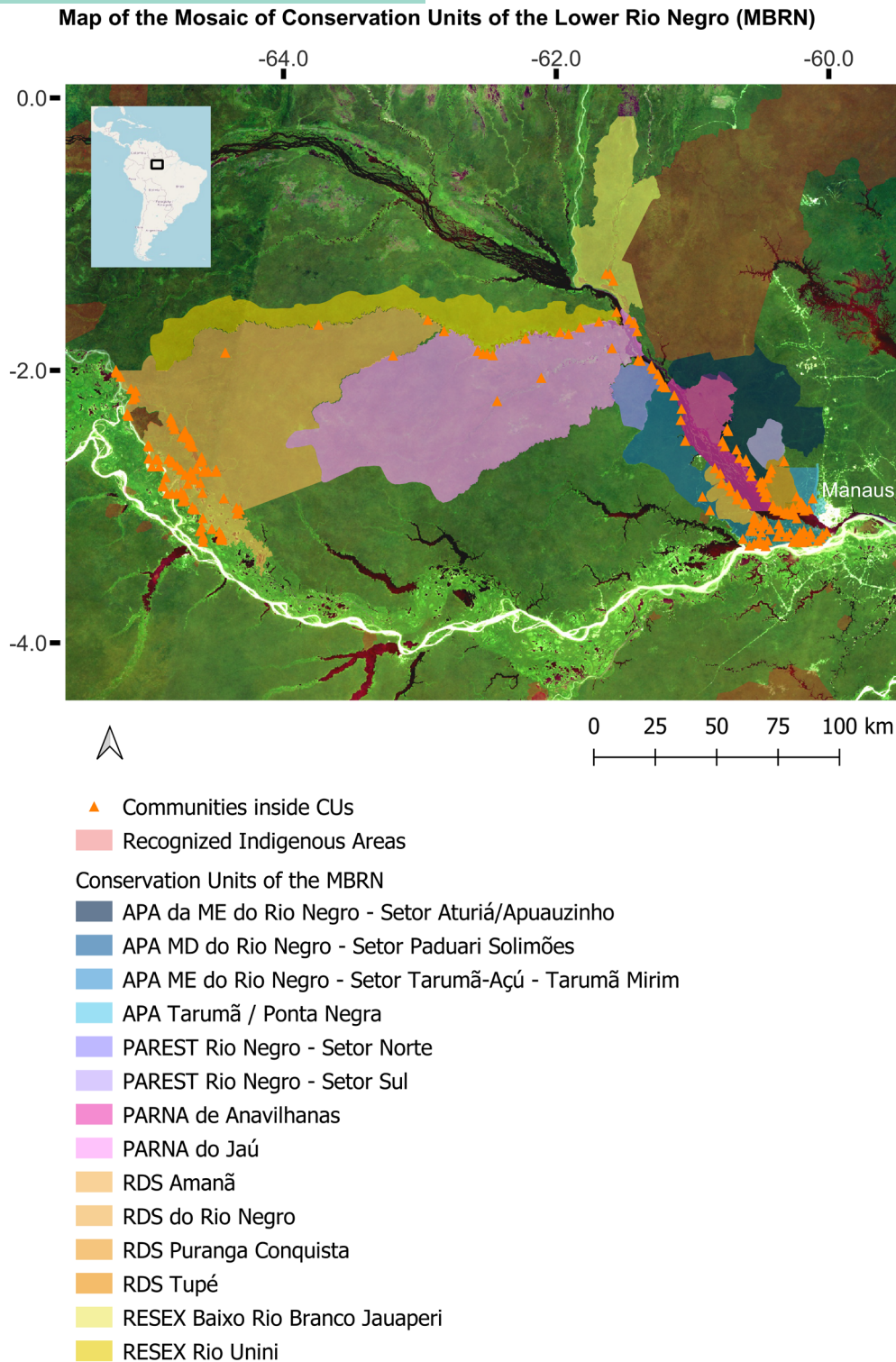


FIGURE 1 Map of the Mosaic of Protected Areas (PAs) of the Lower Rio Negro (MBRN) in 2023: APAs, in shades of blue, are basic Environmental Protection Areas. PARESTs, in shades of purple are State Parks. PARNAs, in shades of pink, are National Parks. RDSs, in orange, are Sustainable Development Reserves; and RESEXs, in yellow, are Sustainable-use reserves. In red, we can see indigenous areas recognized by the State (but not part of the Mosaic), and the small orange triangles are the locations of the communities living within the PAs. Background satellite images from Landsat are a composite from years 2000–2009 (Van doninck & Tuomisto, 2018). GIS data for locations of the PAs and coordinated of the communities living in them are from the MBRN Atlas (Alves & D'Antona, 2023) and the locations of indigenous areas are from the Brazilian government geospatial open data service (FUNAI, 2023). Map design by Ferreira-Aulu & Zuquim (2024) using EPSG:4326–WGS 84 Coordinate Reference System.

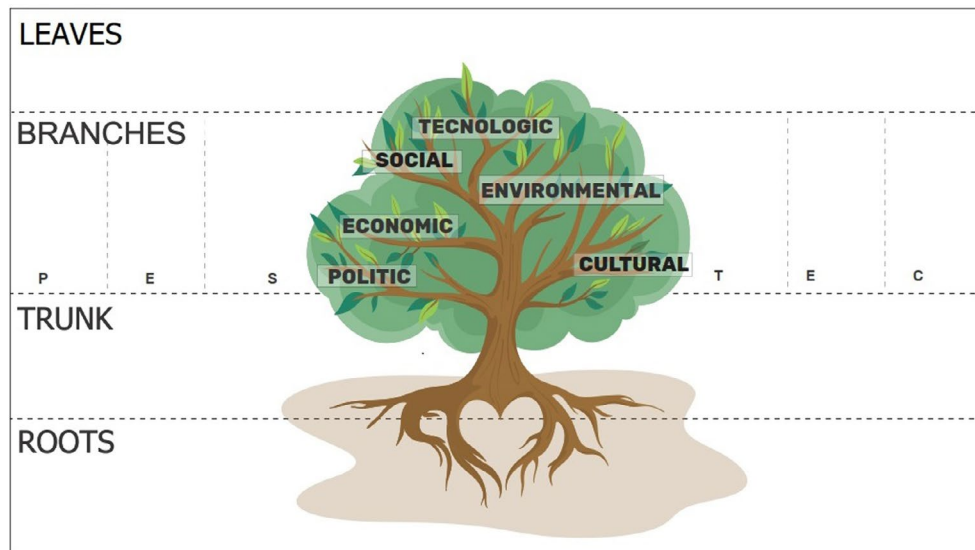


FIGURE 2 Causal layered analysis (CLA)-tree. Novel semiotics for the CLA framework adapted from Milojević and Inayatullah (2015) to an Amazonian visual representation. Each line (or layer) represents one way of describing reality: Leaves (litany), branches (systems), trunk (worldviews) and roots (metaphors and sacred stories). The system's layer is divided on PESTEC aspects based on the Futures Table by Heinonen and Ruotsalainen (2013). Design was developed by Maira Alonso da Costa and Ferreira-Aulu.

employees; the council also includes representatives from organized civil society and local community organizations. This characteristic of the council contributes to a broad and inclusive institutional, territorial and sociocultural perspective of the territory.

2.3 | Workshop framework

Based on Anticipatory Participatory Action Research principles (Bourgeois et al., 2024), the workshop was co-designed with stakeholders, incorporating basics of futures literacy, leadership empowerment and spatial knowledge. This novel combination to futures workshops is called SEFS.

Futures Literacy Laboratory (FLL) is a participatory co-creation method and was used as a basis to structure the workshop agenda (Miller, 2018). FLL was chosen due to its introduction to futures literacy, which was commissioned by the stakeholders. Traditional FLL guides the participants to imagining diverse futures in three phases: *reveal*, *reframe*, *reflect*. In the first phase, participants reveal their hopes and expectations about the future, as well as their own anticipatory assumptions and construct *most likely* (or business as usual) and *preferred* future scenarios. Scenario building is followed by discussions and shared thoughts about the experience (Miller, 2018; Richards, 2022). To apply SEFS, participants of future workshops are divided into groups of four to six participants, to foster good communication and allow opportunities for all participants to express their ideas.

Causal layered analysis (CLA) was used for structuring non-spatial data collection (Milojević & Inayatullah, 2015). CLA is a framework that helps to create alternative futures that integrate various layers of reality and ways of knowing, represented by science, social

sciences, religion and the arts (Ramos, 2015). We modified the CLA visual representation (Figure 2), localizing Inayatullah's pyramid to an Amazonian context.

The canopy of the tree is the litany layer, where participants wrote newspaper headlines that they expect to read in a day in 2040. The branches of the Brazilian nut tree create a large crown, which worked well for the visual representation of the systems level and PESTEC aspects (Political, Economic, Social, Technological, Ecological and Cultural), based on the Futures Table (Heinonen & Ruotsalainen, 2013). The trunk represents worldviews, ideologies and ethics by which the system is operated, and roots represent myths, metaphors and sacred stories that explain the world we live in.

We chose the Brazilian nut tree (*Bertholletia excelsa*), locally known as *castanheira*, because it is a sociologically and economically important species in Amazonia and globally. The individual trees are impressive, being among the tallest and largest trees in Amazonia and, together with the branch architecture, made the species beneficial to the visual representation of the CLA framework. Graphic design was done by Ferreira-Aulu and Alonso da Costa for the workshops ran in July 2023.

A caveat of applying CLA alone is that CLA is not intrinsically considering the spatial heterogeneity of the area of interest. To overcome the lack of spatial representation of CLA, we applied a combination of CLA with participatory mapping or Participatory Geographic Information System (PGIS). The spatial-explicit scenarios were done collectively by drawing on a printed map, so participants could use their hands to draw their input, establishing the feeling of ownership of these scenarios and recognizing the geographical socio-environmental heterogeneity of the region as well as the different threats according to different areas.



FIGURE 4 Participants developing spatially explicit scenarios during a workshop in Novo Airão in 2023. Here, one of the groups identifies potential regional changes for 2040, using stickers and colour markers.

diversity of data collected, each data type was individually prepared for analysis. Qualitative data sources (a, c and d) were systematically organized and thematically coded using Nvivo 14. Spatial data (b) were digitized and processed using QGIS 3.40.5 'Bratislava', enabling analysis of participant-generated maps.

Scenario narratives were recorded both in audio and video format, which were transcribed and translated. Sticky notes were digitized using Microsoft Whiteboard 25.10730.106, maintaining their original layout (Figure 3), and then transferred to Excel 2507.

The hand-drawn maps produced during the workshops (Figure 4) were first scanned and then georeferenced in QGIS to align with real-world coordinates. Each dot placed by participants was converted into a point feature with associated geographical coordinates, and polygons were digitized to represent spatial areas as depicted in the original drawings. The legend co-created by participants during the mapping exercise was used to classify and label the features (e.g. roads, schools and PAs), forming the basis of the attribute table. This attribute table was then exported to Excel for organization and to NVivo for qualitative coding and thematic analysis, enabling integration of spatial and narrative data.

Qualitative data analysis (QDA) was carried out in Nvivo. The workshop notes and outputs were first organized in a structured Excel file, where each row represented a discussion group, and each column captured specific components of the analysis. Although the data were organized by group for practical reasons, our intention was not to compare across groups but to consolidate insights generated throughout the workshops as a whole. The layers of the CLA

framework were arranged across sets of columns to facilitate data organization and interpretation.

The coding process was based on an inductive approach and grounded theory (Maher et al., 2018). We began with thematic coding to identify the main issues and topics of greatest relevance to participants, allowing key themes and recurring concerns to emerge directly from the data.

During the workshops, participants collaboratively developed a *strategic roadmap*: a structured plan outlining shared visions and goals for the management of the MBRN. In the subsequent QDA stage, we further analysed the contents of this collectively built roadmap. Coding at this stage focused on identifying and refining its main components: common visions and goals, actions proposed to achieve them, the necessary resources and competencies, and participants' warnings about potential risks or pitfalls.

2.5 | Research methods ethical considerations

The SEFS method proposed here is participatory and iterative, rather than linear, allowing continuous engagement and flexibility with stakeholders. Reflecting this collaborative process, our list of co-authors includes members from both participant groups (two from UFAM and one from FVA), who contributed to pre-fieldwork discussions, data collection, processing and analysis.

Preliminary results were presented to participants via video-conference in 2024, and a summarized version of the scenarios and roadmaps was shared in-person in 2025. This iterative process

helped build trust, strengthen participants' understanding of the research, and foster shared ownership of the results. Returning to the field to present and validate findings is considered an integral part of our participatory approach.

The SEFS method aligns with principles of citizen participation in science as outlined in the BiodivERsA Stakeholder Engagement Handbook (Durham et al., 2014). This approach draws on methodologies, such as Futures Literacy Laboratories (Miller, 2018), CLA (Inayatullah, 2010; Ramos, 2015), PGIS (Radil & Anderson, 2019) and public participation GIS (PPGIS) (Brown & Kyttä, 2014).

All participants were informed about the study's design, objectives and implications, and were free to withdraw at any time before publication. Each signed a Free, Prior and Informed Consent (FPIC) form permitting participation and the use of images, audio and video recordings for academic purposes.

This research complies with the guidelines of the Finnish National Board on Research Integrity TENK, which does not require an ethical review when research includes FPIC, is focused on adults, does not expose participants to exceptionally strong stimuli, does not involve a risk of causing mental harm, nor does it involve a threat to the safety of participants.

The study follows the ethical guidelines of the Finnish National Board on Research Integrity (TENK), which does not require formal ethical review when adults provide FPIC and the research poses no significant psychological or physical risk. Although the fieldwork did not occur inside PAs, participants were associated with them; thus, appropriate permits were obtained from ICMBio and the Brazilian Ministry of the Environment (Permit No. 90341-1).

3 | RESULTS

The results presented here are a summary of 12 SEFSs for the year of 2040 co-created during workshops held in July 2023, combining the six probable and six desirable futures in two subchapters. Each of the 12 scenarios had a set of three types of outputs: CLA boards with sticky notes, maps and narratives. These outputs were also discussed in plenary to generate a common view of 2040 scenarios and actions needed towards a desired 2040.

3.1 | Narratives

3.1.1 | Probable scenarios

In general, all groups described a probable scenario for the year 2040 as a future in which local citizens have very little agency in decision-making. In these scenarios, Amazonia faces environmental decay, economic instability and high levels of corruption, as exemplified in the following statements for 2040:

Environmental agencies remain unequipped to combat illicit activities;

Secretary of the Environment loses his last strands of hair;

Bouto Curumim is an Amazonian pink dolphin from the Rio Negro. It hunts fish contaminated by mercury from illegal mining in the Rivers Branco and Negro, and ingests plastic waste.

Probable scenarios for 2040 described a weakened community autonomy due to high economic dependence on external resources. In spite of lack of resources, local leaders would endure a continuous fight for resilience, making stronger alignments with NGOs and with the scientific community. In these scenarios, land tenure regularization continued to be a challenge. The rise of deforestation and lack of indigenous area demarcation would rise real estate speculation, putting traditional communities' land ownership at risk, as shown in this statement for one of the 2040 probable scenarios:

Economic imposition is increasingly observed, such as a high rate of real estate speculation, resulting in greater deforestation and pollution in the region.

According to the participants, an intensified predatory economy could mean private initiatives would have a greater impact in the region's economy, taking away the communities' agency.

As a metaphor for the role of the council of leaders of the MBRN, participants told us about a local legend of the manatee that sank an island home to predatory hunters, explaining that leaders of the Mosaic work together with nature to defend the forest and its peoples.

3.1.2 | Desirable scenarios

Desirable futures were imagined from a reframed future possibility in which workshop participants would take a leading role on the future-making. A driving question was 'If leaders of the Mosaic had the agency to change the course of the future; how would this future be like instead?'

In general, desirable futures were presented in a much more creative manner than probable futures. Groups improvised theatre plays, composed songs and wrote open letters. Preliminary data analysis was presented to participants in a videoconference in 2024, and a summarized version of all narratives produced was presented back to participants in-person in 2025. The group approved the following consensus of a desirable scenario:

In a desirable future for 2040, communities of the MBRN have self-sufficiency and autonomy, and the Mosaic of the Lower Rio Negro experiences a functional co-management of resources. All Amazonian indigenous lands are recognized by the State; traditional communities are not excluded from society, and there is a functioning Local Productive Arrangement (LPA).

In desirable scenarios for 2040, young leaders have academic degrees and qualified labour. The State of Amazonas would have several rural campuses with courses on topics related to small-scale agriculture management, agroecology, hydroponics and other new types of agriculture. Contemporary anthropology, environmental sciences, indigenous medicine and identification of wild medicinal herbs, indigenous language studies, entrepreneurship and solar panel maintenance; Information Technology (IT) were also among the topics mentioned for the desirable 2040. Other skills that would be developed in the region were media literacy, technological literacy, legal processes literacy, as well as the capabilities to write project funding applications.

In 2040, all MBRN communities are powered by solar panels, as are most boats and watercraft in the region. This will be possible by fomenting public policies for the implementation of solar power, as well as public and private subsidies.

Economic sustainability in a desirable future includes carbon offset and Brazilian Development Bank grants not as primary funds to communities, but as complementary income. Community members have their income mainly based on tourism, small-scale farming, production of local goods and an accessible market beyond the city of Manaus.

In desirable scenarios for 2040, the city of Novo Airão would be a reference for well-organized tourism in the North of Brazil. The region would have developed infrastructure to host national and international tourists, the MBRN would have a sustainable economy and education in traditional communities as high priority for the government. In desirable scenarios, the Council of leaders of the MBRN would take a major role as guardians of the forest and would have an important contribution to mitigation of global climate change.

In the narratives, a collection of heroes, both real and mythological, was raised as representants of the protection and resilience of the forest peoples, as exemplified in the two narratives below:

Narrative A:

24 July 2040. Open Letter in celebration of 30 years since the creation of the Mosaic of Protected Areas of the Lower Rio Negro (MBRN).

Good news about the contribution of the Mosaic to the world. Due to conservation efforts in Amazonia, the global average temperature has lowered 1°C from pre-industrial times. The MBRN has today 7.5 million hectares of protected area, everything we hoped for 30 years ago when the Mosaic was created.

Sustainability projects are highly promoted; we use only clean energy. Our energy matrix is completely different from when the Mosaic was established back in 2010. We do not see any more watercrafts or cars using fossil fuel, now they are all either electric or

solar powered. We had an incentive for sustainable management in the economy, and compensations for reforestation projects. We no longer have areas under pressure.

We also have adopted sustainable practices with individuals: people are reforesting their private lands, and the predatory economy we used to see 30 years ago has completely vanished. Those who believe in change finally managed to gain majority in government, and we managed to change reality.

Narrative B: Song, written in Tukano (indigenous language widely spoken in Negro River region), and translated by the composer to Portuguese, and to English by the authors of this paper:

Mirin Kuãporã wãkantoarã wessamã

Deró Vé mabrin sarevhsã

Mérem siruturansa

Murém mairãnsa

Té veriunãmpé

Massãn Kuraríu

Vankantoarã vessama

Deróvé mahnisari vhsá

Mërem sirutinansa

Mure mainrãnsã

Té Verirampu

This song I wrote here, just now. I imagined waking up on 24 July 2040. So, when we wake up in 2040, we notice that the first ones to wake are the birds. So, the song refers to them. Then, humanity wakes up, in the morning of 26 July 2040. And lastly, the directors of our Mosaic wake up in a new world. So, the verse says: 'what shall we do now?'. Birds, humanity, all together with the leaders of the Mosaic. We will fight together from now on. United until death.

In other narratives, mythological creatures such as the Curupira, the protector of forests and lara, the protector of freshwaters, represent the role of the council of the MBRN in the region as guardians of the forests and waters. Moreover, several contemporary MBRN council members were included in the scenarios as 'real life heroes',

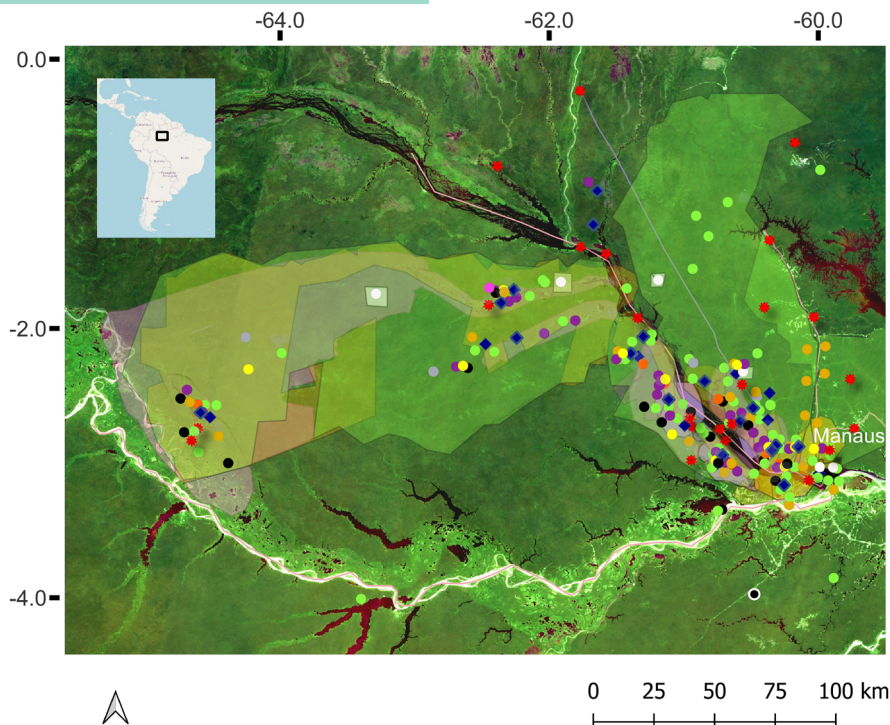


FIGURE 5 Consensus Map: Composite of Spatial Data produced during workshop digitized and georeferenced in QGIS (all groups combined). Background satellite images from Landsat are a composite from years 2000 to 2009 (Van doninck & Tuomisto, 2018).

as well as names of iconic environmental activists killed in recent history, such as Bruno Pereira, Dom Philips, Gabriel Gentil and Chico Mendes.

3.2 | Participatory maps of futures

Each map or scenario produced by the different workshop groups was digitized as a separate layer in QGIS. To synthesize the collective input, all layers were overlaid and stacked to generate a consensus map (Figure 5) integrating all spatial elements identified across groups. Spatial data analysis was conducted using QGIS V. 3.40.5. 'Bratislava'. The spatial-explicit scenarios developed included features, such as proposed roads, locations of future activities, solar panels and other infrastructure elements.

Based on the interpretation of the spatial data, polygons in general represented entire PAs, while lines typically denoted transportation systems, such as roads and rivers. Many features initially marked as points were found to refer to broader areas rather than specific coordinates. These were therefore translated into polygons to better reflect their intended spatial extent. For this regional-scale map, depicting roughly 80,000km², we noticed that the input provided by participants was not highly specific or precise locations, which is a common phenomenon often discussed in participatory mapping literature.

Most mapped points were concentrated in the PAs near the city of Manaus, located in the Southeast of the Mosaic. Most points designated to community-based tourism (CBT) were in PAs closest to

Manaus, where communities have better access to roads, electricity and other basic infrastructure.

3.3 | Thematic analysis of CLA

The thematic coding of CLA, narratives and map data in Nvivo yielded 2027 references. Following the coding process described in the methods chapter, the issues of most relevance under discussion identified are summarized in Table 1.

The sustainability of the local governance, and especially governance of the commons (common pool resources) was among the most mentioned topics in the workshops. Within this topic, it was clear in the discussions that the council of leaders of the MBRN perceived their work as important not only for the communities they represent, but also to the planet, as they are responsible for fighting for the protection of wildlife.

An important concern repeatedly raised under the education and training theme was the possibility of traditional communities' rural exodus to urban areas. It was discussed that this migration could be a threat to conservation projects and to traditional riverine cultures. Workshop participants extensively discussed the feasibility of online education and the organization of specialized training inside local communities as a way to prevent such phenomena.

Another recurrent topic was related to concerns towards the sustainability of project-based conservation activities. This was reflected in an interest of the workshop participants in improving

TABLE 1 Issues with most relevance under discussion during workshops according to thematic coding made using Nvivo. Shapes and colours on the left refer to the spatial explicit data shown on the Consensus Map (Figure 5).

Shape in map		No. of references
◆	<i>Role of local governance</i>	291
	Governance of Common Pool Resources (CPR)	72
	<i>Strengthening the local economy</i>	225
●	Income from carbon offset	102
	Fair income distribution and well-being	68
	Dependence on external investment	50
	<i>Tourism</i>	172
	Community-based tourism	73
●	Ecotourism	40
	<i>Sustainable energy</i>	99
●	Locations for new solar panels	97
	Solar energy as a potential solution	59
●	New technologies bringing potential solutions to the region	97
	Education and training	82
★	Violent areas	56
	The importance of a mindset changes in society	53
○	Healthcare to communities	48
●	Young people taking on leading roles in their communities	48

capabilities to write project funding applications. Local leaders expressed the interest to define their own terms for these projects and take a leading role in their own activities. They also recognized a gap in the know-how in writing applications. Moreover, once funded, there is a need for the know-how to manage these resources independently. Currently, these activities are, in general, led by NGOs.

Tourism was largely perceived as a solution to the economic growth of the communities inside conservation areas (172 mentions). Community-based tourism and ecotourism are the most popular choices for tourism development in the region. Wellness and traditional-healing tourism were also discussed.

Workshop participants emphasized repeatedly the need to avoid large-scale predatory tourism. To develop CBT in the MBRN and attract tourists, it was recognized that some basic infrastructures are currently needed in the local communities. Accessibility to electricity through sustainable sources intrinsic to the sustainable development of the region was among the common topics, and solar power was considered the best bet for a sustainable solution for the region.

3.4 | Collective vision for 2040

In plenary, we defined a collective vision for the MBRN region and looked into actions, resources and competences needed to

achieve the vision. The collective vision describes a sustainable MBRN, with a functioning governance of the commons. In plenary, we produced the below text that was read and approved by all participants:

Collective Vision for the MBRN 2040

Leaders of the local population and organizations will be fundamental stakeholders in decision-making processes. Leaders will be a legitimate representation of the interests of the communities. Communities will take the leading role of their own realities and are valued in society. Governance of the commons in the MBRN will be so well functioning that it has become a reference of high-quality democratic leadership to Amazonia, to Brazil, and to the world.

In 2040, most young adults will have professional degrees. All MBRN communities will enjoy a fully implemented sewage system, have access to electricity, and an integrated network of communication. Thanks to these, the various niches of the MBRN such as tourism, entrepreneurship, gastronomy, art & culture will be well structured, and the peoples of the MBRN will not need to depend on social benefits from the State.

3.5 | Strategic roadmap

Based on the collective vision co-created, the strategic roadmap was co-produced focusing on key actions and needed competencies. Some of the immediate actions to achieve the 2040s vision according to the participants are highlighted, based on what they perceived as most important:

- Decentralization of the management and surveillance of natural resources, with a more significant role of local communities in decision-making;
- Strengthening local associations, cooperatives and community-based management, even if such efforts would initially rely on volunteer work;
- Ensuring the legitimacy of this leadership, once the community-based management becomes formalized;
- Permanent contracts for employees in environmental agencies to ensure long-term actions;
- Improvements in the current system of Rural Environmental Register (CAR);
- A more significant role for the Centre for Conservation Units of Amazonas (CEUC) in climate change adaptation strategies.

It is worth mentioning that in the roadmap exercise, it was realized the need for training and the development of certain skills for the next generation of leaders to ensure that these actions are successful. The most urgent competency noted was communication skills, to allow community leaders to have meaningful conversations with governmental officials. It is, therefore, envisioned that by 2030, the MBRN will have well trained, qualified young leaders holding seats on the council and other decision-making positions.

4 | DISCUSSION

Based on the SEFS framework which integrates scenarios, thematic analysis and spatial mapping, we identify the following critical findings:

1. Governance of the commons is a central pillar for sustainable futures in the MBRN, with leaders envisioning themselves as legitimate guardians of forest and water resources.
2. Education and training are perceived as both opportunity and risk: while necessary for empowerment, they risk accelerating rural exodus unless alternative models (online or rural campuses) are implemented.
3. Economic Sustainability through diversification of local economies; community-based tourism; small-scale agriculture; and renewable energy is seen as the main pathway to reduce dependency on external investment.
4. Solar energy is the most widely accepted technological solution for sustainable development, with visions of fully solar-powered communities and boats by 2040.

Moreover, spatial distribution of priorities shows concentration of opportunities and risks near Manaus, underscoring uneven infrastructure and accessibility across the Mosaic. We below discuss each of these findings.

4.1 | Co-governance

In a desirable future, MBRN is a model of well-functioning co-governance. This leadership view is aligned with the scientific literature on governance of the commons in Amazonia, for example Carlsson and Berkes (2005), Acosta et al. (2018) and Franco et al. (2021). Carlsson & Berkes define co-governance as the sharing of power between the State and communities; it is a complex type of governance because it involves extensive deliberation, negotiation and joint learning within problem-solving networks (Carlsson & Berkes, 2005). Acosta et al. suggest that this governance strategy could be the most successful in the Amazonian context (Acosta et al., 2018); while Franco et al. argue that community-based environmental protection systems are a legitimate mechanism of socio-environmental governance in the areas they operate in, allowing for consensus among users for the adequate management of natural resources, especially in contexts in which government actions are absent or inefficient (Franco et al., 2021).

Workshop results indicate that participants believe they play a significant role in local conservation efforts and general planetary well-being. However, they also expressed concerns that their resilience is being compromised by high levels of uncertainty.

4.2 | Education and training

In terms of demographics and education, a notable paradox emerges as communities acknowledge the critical importance of education and specialized skills for community empowerment yet are apprehensive about sending their potential young leaders to urban settings for obtaining the necessary degrees. This apprehension derives from a persistent trend where young individuals migrating to urban areas often fail to return to their traditional communities. This dualism between staying in the community or moving to the city for the aspiration for 'good life' is present in many contexts within Amazonia and has been documented previously, for example in the works by Virtanen (2012) and Dodd (2020). While some individuals might find moving to the city is 'difficult and inconvenient since they have to do lots of work there and the money earned is merely enough to buy food' (Virtanen, 2012), others see it as an opportunity to become autonomous and to create the 'ability to choose what type of livelihood they want and how to live their life in the reserve as well as outside of it' (Dodd, 2020). This apprehension and dualism are true not only in Brazilian Amazonia but also in other Amazonian countries. Barbieri and Carr (2005), for example, argue that riverine populations in Ecuador are intrinsic to forest preservation, as deforestations happen more often in less occupied or unoccupied areas. Virtanen (2012) foresees that the migration

trend is likely to continue in the future: 'the movement to urban areas continues because these spaces represent transformative power, knowledge, and desired capacities' (Virtanen, 2012, p. 113). An alternative lies in online training, and this strategy seeks to enhance the educational opportunities available to forest peoples while retaining young leaders within their native communities. The concept of long-distance education is not new in the region. The Federal University of Amazonas (UFAM), for example, has had long-distance courses since 2007 (UFAM, 2024a). Online training, however, is still a challenge due to the lack of basic infrastructures in the region, such as stable access to electricity and the internet in the communities.

Another envisioned solution for the future of education was the establishment of rural university campuses. Small campuses in the inner country already exist in Brazil. The Federal University of Amazonas, for example, has five campuses in smaller municipalities (Parintins, Benjamin Constant, Coari, Humaitá and Itacoatiara, UFAM, 2024b). Most recently, the Brazilian Ministry of Education announced a goal to create the first Brazilian Indigenous University (Brazilian Ministry of Education, 2024), although no concrete plans have been published. This could potentially bring a positive impact on the well-being and strengthening of indigenous languages and cultures, and a unique opportunity for straightening the ties between traditional and scientific knowledge.

4.3 | Economic sustainability

Currently, a considerable part of conservation activities in the MBRN are funded by external resources, the larger funders being the international carbon-offset market, the Amazon Fund and the Brazilian Development Bank (BNDES), and the income is usually project-based. It was raised that in order to reach economic sustainability, local communities cannot depend exclusively on external investment.

A recurrent economic alternative proposed was CBT, which is described in the literature as the development of tourist locations in a planned manner with the aim to conserve natural resources, while at the same time valuing local culture and protagonism (Lima et al., 2022). CBT exists in Amazonia and is largely associated with sufficiency, environmental protection and the well-being of local populations (Lima et al., 2022), which are all common goals of the workshop participants.

Examples of CBT already exist today in the MBRN, such as the Nova Esperança community, located in the Puranga Conquista Reserve. There, Baré families host tourists in their homes. Tourists eat traditional food, participate in daily activities and join handicraft workshops (Ipê, 2024). CBT is considered responsible and sustainable tourism and is part of the UN agenda 2030 (Inskeep & Weston, 2000; UNWTO, 1998).

4.4 | Infrastructure development

Infrastructure development was explicitly discussed when we produced a common vision for 2040. It was clear that the implementation

of a sewage system, access to electricity, an integrated network of communication and infrastructure for recreational activities is necessary.

In 2023 a population census was conducted in the region by the University of Campinas (Alves & D'Antona, 2023) including 120 communities from the MBRN. Of those, only 29 have healthcare centres and 18 have an ambulance-boat for emergency transport to the nearest hospital in Manaus. The census also showed that 73 communities have access to clean water, 95 have schools, 66 have access to internet, and 35 have access to cell phone signal (Alves & D'Antona, 2023). Only 34 of 120 communities have access to electricity from the national electricity grid, and all of these are communities near the city of Manaus. When going further away from main cities, the main source of electricity is the generator (63 communities), and 9 communities are powered by solar panels. Technological advancements of solar panels and the decreasing costs of this technology in the long-term are largely seen as an opportunity.

4.5 | Added value of SEFS workshop

The relevance of the workshop and its results are multi-fold. The workshop per se had an impact in the governance of the MBRN as it served as an opportunity for council members to momentarily leave pressing problems aside and to think long term. The workshop enabled participants to co-create futures imaginaries and establish common ground. The process empowered conservation unit leaders towards a more resilient leadership. In practical terms, the co-created scenarios had an immediate result on the decision-making discussions, as it made clear that despite the differences within groups, all participants shared a common goal to preserve the natural habitats of their PAs and to collaborate with one another for the success of their activities. The spatial-explicit approach provided a good complement to the traditional CLA framework. The sheer area of MBRN embraces heterogenous contexts, from urban areas to communities that can only be accessed after several hours in a motorboat. It is worth noting that the spatial-explicit approach provided us information about areas within the MBRN with most concerns or potentials for action plans, and these points of reference are more valuable to council members themselves than they are for us researchers. This allows local action and financial resource allocation in relevant spatial scales and levels of governance, for example, at the municipal level.

5 | CONCLUSIONS

This research set out to understand what kinds of futures people working in PAs of the Lower Rio Negro imagine and hope for the region. The findings reveal a shared desire for a future grounded in local autonomy, collective responsibility and long-term ecological conservation. Participants envision governance systems that strengthen the legitimacy of local leaders in decision-making processes rather

than centralized, external authorities. Although governance of the commons is time-consuming and requires constant negotiation, it is perceived as the most reasonable and legitimate foundation for enduring conservation, less susceptible to the volatility of national and regional politics.

Imaginations on the future of the economy in the region centre on resilience and independence. Results show that participants imagine livelihoods that are versatile, diverse and locally sustained. Initiatives such as CBT illustrate the ambition to combine opportunities for income with the protection and sustainable use of natural resources. Other sustainable economic activities and professional training are seen as essential for reducing external dependence. This imagined economy supports not only ecological goals but also social dignity and self-determination.

Participants imagine futures where governance and education systems are suitable to Amazonian realities rather than imported from external models that fail to reflect regional social and ecological conditions. Such models, coupled with investment in essential infrastructure like renewable energy, sanitation, independent communication networks and recreational spaces, are seen as critical to improving well-being while reinforcing commitment to socio-environmental sustainability.

Addressing Amazonia's socio-environmental challenges requires innovative and inclusive approaches which empower communities and promote sustainable futures. Spatial-explicit scenarios is an example of such an approach. Our study shows that the co-created scenarios are the central results of the SEFS approach.

The SEFS methodology developed and applied here is a transferable tool that integrates futures literacy, leadership empowerment and spatial knowledge, offering valuable insights for conservation planning beyond this case study or Amazonia.

These insights should guide policymakers and stakeholders towards actionable and inclusive conservation strategies, aligning investments and governance structures to support local leaders as protagonists of sustainable development.

To sum up, the futures imagined by people working in PAs portray a region that is community-led, sustainable and resilient to political upheaval. By embedding ecological care, economic autonomy and social learning within local institutions, these visions outline an Amazonia that is less volatile, more adaptive and better prepared to navigate uncertainty while safeguarding both the forest and its people. It is essential for policymakers and stakeholders to embrace these insights, fostering collaborative governance towards more just and sustainable futures.

AUTHOR CONTRIBUTIONS

Marianna Birmoser Ferreira-Aulu: Conceptualization; data curation; formal analysis; funding acquisition; investigation; methodology; resources; validation; visualization; writing—original draft; writing—review and editing. **Marina Antongiovanni da Fonseca:** Conceptualization; investigation; writing—review and editing. **Sissi Mikaella de Araújo Bittencourt:** Investigation; methodology;

writing—review and editing. **Xadrique Vitorino Macuácu:** Investigation; methodology; writing—review and editing. **Gabriela Zuquim:** Conceptualization; methodology; validation; funding acquisition; supervision; Visualization; writing—review and editing. Our study brings together authors based in Finland and in Brazil. The diverse perspectives of authors from Brazil, Finland and Mozambique are represented in the study. Literature published by scientists from the region under study was of critical importance in the study and this paper.

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CONFLICT OF INTEREST STATEMENT

The authors declare that they have no conflicts of interest related to this study. All authors have contributed to this research independently, and there has been no involvement of any commercial or financial relationships that could be construed as a potential conflict of interest.

PEER REVIEW

The peer review history for this article is available at <https://www.webofscience.com/api/gateway/wos/peer-review/10.1002/2688-8319.70248>.


DATA AVAILABILITY STATEMENT

The data that support the findings of this study have been deposited in the Fairdata repository (Ministry of Education and Culture/CSC, Finland) and are openly available: <https://doi.org/10.23729/fd-464329bc-ffd4-30d3-b97b-d60cd5ee242e>(Ferreira-Aulu, 2026).

AI USAGE STATEMENT

Artificial intelligence support was employed only during the revision and language-editing phase of this manuscript. The tool used was a closed-loop version of ChatGPT provided by the University of Turku, accessed via the university's secure server (sign-in with UTUSSO). Additionally, co-authors who are not fluent in English used the same closed-loop AI environment to support their reviewing and commenting process. All research design, analysis and interpretation remain the sole responsibility of the authors.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

Annex 1. Workshop participants.

Supporting Information S2. Workshop Structure.

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