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RESEARCH ARTICLE

Stakeholder perspectives on nature, people and sustainability at Mount Kilimanjaro

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Abstract

1. Effective approaches towards sustainability need to be informed by a diverse array of stakeholder perspectives. However, capturing these perspectives in a way that can be integrated with other forms of knowledge can represent a challenge.
2. Here we present the first application of the conceptual framework of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) to a participatory assessment of local perspectives on nature, people and sustainability on Mount Kilimanjaro, Tanzania. This assessment was organized in the form of a participatory workshop with five different groups of stakeholders.
3. Following this framework, we assembled information on the state of and trends in species diversity, Nature's Contributions to People (NCP), and on the main drivers of changes in species and habitats. Additionally, we gathered perspectives on the needs and opportunities for the sustainable management and conservation of natural resources from the individual to the international level.
4. The various stakeholders agreed that both the condition and extent of the various habitats and NCP are declining.
5. In line with available knowledge, the key direct drivers of change mentioned by the workshop participants were land use and climate change, whereas human population growth was singled out as the most important indirect driver.

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6. The most frequently suggested measures to address the observed decline in species diversity and its drivers were related to land and water management and to education and awareness raising. Yet, the stakeholder groups differed in the measures they suggested.
7. The willingness of a diversity of knowledge holders to systematically engage in a structured discussion around all the elements of the IPBES framework provides support for its applicability in participatory workshops aimed at capturing nuanced and context-based perspectives on social–ecological systems from informed stakeholders.
8. The application of the IPBES framework enabled the comparability needed for developing narratives of stakeholder visions that can help identify new pathways towards sustainability and guide planning while retaining the context-based nuances that remain unresolved with non-participatory methods.

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KEYWORDS
participatory workshops, IPBES, Tanzania, East African mountains, mountain biodiversity, Nature's Contributions to People, ecosystem services, social–ecological system

1 | INTRODUCTION

Effective approaches to sustainability challenges require both a global perspective and an in-depth understanding of local social–ecological systems (Martín-López et al., 2020), which are traditionally accessed through literature and field measurements. Both global and local understandings and perspectives also reside with local stakeholders and can be elicited through dialogues and social assessments using different forms of knowledge mobilization and sharing as well as various methods from the social sciences and humanities (Lakerveld et al., 2015; Orenstein & Groner, 2014; Tengö et al., 2017). By placing stakeholders at the centre of the research, social assessments complement the predominantly ecological and economic approaches typically adopted in ecosystem-related assessments and that might overlook relevant social aspects (Orenstein & Groner, 2014; Raymond et al., 2013; Scholte et al., 2015). They further enable to embrace the diversity of perspectives on nature and its management residing among different social groups and stakeholder segments (Brondízio et al., 2021), whose views are affected by different social, economic and cultural factors, including prior knowledge and involvement in local management and sustainability initiatives (e.g. Caballero-Serrano et al., 2017; Cuni-Sanchez et al., 2019; Lamarque et al., 2011; Lewan & Söderqvist, 2002).

Local perceptions are particularly relevant as they may capture knowledge that is not yet recorded and because they are often influential in guiding decision-making, justifying actions (Orenstein & Groner, 2014) and resolving conservation trade-offs (e.g. Cuni-Sanchez et al., 2019). Accordingly, the integration and weaving of knowledge from academic and non-academic origins through a process of co-production is key to addressing complex sustainability questions (Norström et al., 2020; Tengö et al., 2017). The collection of contextualized information that accurately captures a diverse array of local stakeholder perspectives on social–ecological systems and their conservation and that can be weaved with quantitative desktop findings is methodologically challenging. Yet it offers powerful perspectives for comparisons across scales, geographies and contexts, and for the just accounting of local grassroot knowledge and needs. In this context, the conceptual framework of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES, Díaz et al., 2015) represents a unique opportunity to take up the challenge.

Here we report on a first attempt to apply the IPBES framework in a participatory assessment of nature, people and sustainability on Mount Kilimanjaro as a structured tool for capturing stakeholder perspectives. We further highlight how these perspectives reveal salient differences between stakeholder groups and enrich current narratives on the relationship between nature and people around Mount Kilimanjaro as well as on options for decision-making and action towards a more sustainable future.

1.1 | Mount Kilimanjaro social–ecological system

Mount Kilimanjaro is the highest free-standing mountain in the world (Newark, 1991) and hosts approximately 2,500 plant and a few hundreds bird species. The classification of its elevational zones is a matter of perspective (Hemp, 2006a; Hemp & Hemp, 2008; Liseki, 2015; Misana, 2012; Molina-Venegas, Fischer, & Hemp, 2020; Soini, 2005a). Habitat classification based on agro-ecological systems and local perceptions delineates a highland zone including the coffee-banana belt and (Chagga) home garden area (1,200–1,800 m a.s.l.), a midland zone characterized by the maize-bean belt (900–1,200 m a.s.l.) and a lowland zone (<900 m a.s.l.) characterized by extensive livestock grazing. Scientists in turn distinguish up to 12 major habitat types along the elevational gradient (colline savanna, submontane-lower montane rainforest, *Ocotea* forest, *Podocarpus* forest, *Erica* forest, alpine *Helichrysum* vegetation, *Erica* forest shifted to lower elevations due to disturbance, logged *Ocotea* forest, meadow, Chagga home gardens, coffee plantations and maize fields, Hemp, 2006b).

Mount Kilimanjaro is home to approximately 1.3 million people (United Republic of Tanzania, 2013), the majority of which lives in the Chagga home gardens (Fernandes et al., 1985). These home gardens are unique, sustainable and well-developed agroforestry systems that have been in use for centuries (Fernandes et al., 1985; Hemp, 2006a; Hemp, 2006b; Misana, 2012; Newark, 1991; Sébastien, 2010; Soini, 2005a). However, over the last decades, these systems have been faced with numerous challenges associated with human population growth and changes in land use (Hemp & Hemp, 2008; Misana, 2012; Sébastien, 2010; Soini, 2005a).

The critical importance of Mount Kilimanjaro's natural resources for people's well-being and livelihoods (e.g. Mount Kilimanjaro is the main source of water for the 42,200 km^2 large Pangani river basin (Hemp, 2005; Sébastien, 2010) and an important reservoir of useful plants (Molina-Venegas, Fischer, Mollel, et al., 2020; Mollel et al., 2017)) and its importance as a popular destination for economically important international tourism (Adili & Robert, 2016) calls for efforts to ensure its conservation and sustainable management. The recent conservation history of Kilimanjaro started in 1904 with the protection of the 'Mount Kilimanjaro Forest' (Newark, 1991) and continued with its classification as a natural reserve in 1921 (Sébastien, 2010) and the establishment of a half-mile forest strip below the reserve in 1941. This forest strip was established as a social buffer to provide local people with wood and other forest products (Newark, 1991). Major milestones in recent history include the reclassification of the area above the upper forest border (i.e. > ~2,700 m a.s.l.) as a national park in 1973, the listing of the National Park as a UNESCO World Heritage Site in 1987 and the establishment of community-based forest management practices for the half-mile forest strip in 1998. Under its current status, Mount Kilimanjaro National Park belongs to the 40% of Tanzanian land that is already under protection, and which the international community is committed to further increase (Keane et al., 2020). Despite numerous conservation measures, the Mount Kilimanjaro National Park and its adjacent forest belt and habitats face many threats, including logging, quarries, livestock grazing, cultivation within the forests, poaching, charcoal production and outbreak of fires (Hemp, 2006c; Lambrechts et al., 2002; Liseki, 2015; Misana, 2012; Noe, 2014; Soini, 2005a).

1.2 | The IPBES conceptual framework

The IPBES conceptual framework is a simplified model of the complex interactions between the natural world and human societies. It identifies six components representing the natural and social systems and specific links between them: (a) nature (biodiversity and ecosystems, herein species diversity and habitats), (b) Nature's Contributions to People (NCP, the contributions that people derive from nature (Díaz et al., 2018)), (c) human well-being (good quality of life), (d) direct and (e) indirect drivers of change and (f) anthropogenic assets and their interrelations. Direct drivers include climate- and land-use change, over-exploitation, invasive species and pollution, while indirect drivers include demographic, economic, technological, policy and institutional as well as cultural factors. IPBES explicitly calls for the inclusion of multiple knowledge systems, such as Indigenous and Local Knowledge (ILK), in analysing and assessing social–ecological systems (Díaz et al., 2015). As such, it addresses the fact that representations of human–nature relationships may vary across cultures and knowledge systems according to specific worldviews and cosmologies, including between scientific and ILK systems, as well as among indigenous cultures.

2 | METHODS

2.1 | Stakeholder workshop

We conducted a 3-day stakeholder workshop in Moshi, Tanzania, in September 2018. The workshop was attended by 73 participants (16 women and 57 men), whom we invited to represent various sectors and local communities. We established the list of invitees through an extensive online search validated and complemented by key local informants. We divided registered participants into five groups based on their sectoral affiliation: 16 residents of local communities, including farmers (herein 'Community'), 14 researchers and scientists ('Research'), 16 professionals in conservation and management ('Conservation'), 17 professionals in forestry, agriculture and water management and governance ('Resources') and 10 other professionals mainly drawn from the tourism sector ('Other'). Each of these groups was moderated by one facilitator and a chair elected among the members of the respective groups. The primary language was English, but workshop material was also available in Swahili. Swahili was also used for discussions, particularly in the 'Community' group.

2.2 | Data collection

We used three data collection methods: (a) moderated group discussions, (b) individual questionnaires and (c) a 'carousel-like' session. We conducted regular plenaries to set, explain and recall the workshop context as well as the elements of the IPBES framework, to report back from group discussions and to gather feedback.

2.2.1 | Moderated group discussions

The group discussions aimed to establish a common understanding within the five stakeholder groups of the various sections and elements covered by the questionnaires (see Section 2.2.2). In the first discussion, each group distinguished different types of habitats and agreed on a typology that was subsequently used in the questionnaires. This discussion was based on a preliminary mapping exercise during which each participant was asked to identify her/his geographic area of expertise on a printed map of the region depicting major habitat types. While we recorded the different areas of Mount Kilimanjaro for which participants conducted the assessments, we did not specifically interrogate their definitions of the concept of 'nature', which can vary between cultures and languages (Coscieme et al., 2020). During three subsequent discussions, the groups listed and valued important species (IPBES component 1), NCP (IPBES component 2) and drivers of change (IPBES components 4 and 5). During the discussion on species, participants were asked to indicate the use of individual species, whereas during the discussion on NCP, they were also asked to discuss the habitats providing them as well as their status, trends and future provision. During a last discussion before the carousel session, each group formulated a shared vision for a sustainable future for Mount Kilimanjaro where people live in harmony with nature.

2.2.2 | Questionnaires

We used two questionnaires—herein 'habitat' and 'ecosystem services'—with open and closed questions (Supplementary Material S1). Closed questions were scored using a Likert-type scale. The 'habitat' questionnaire collected individual perceptions about the state of and trends in habitats and species diversity and about the direct and indirect factors driving these trends (i.e. IPBES components 1, 4 and 5). We invited participants to fill in separate questionnaires for each habitat of importance to their sector (as defined during the group discussion, see section 2.2.1) or for which they had knowledge, starting with the most important ones. The 'ecosystem services' questionnaire collected individual perceptions about the state of, trends in and importance of NCP (i.e. IPBES component 2), as well as about the factors driving observed changes in access and provision. With reference to the preliminary group discussion on NCP (see section 2.2.1), we invited participants to fill in separate forms for each NCP they deemed important to their sector or had knowledge about and to indicate which habitat(s) provide(s) each of them. Participants had between 45 and 60 min for each of the two questionnaires and were encouraged to fill in as many forms as possible. Although we used the more familiar concept of ecosystem services during the workshop, we classified these into NCP for our analyses using the classification included in IPBES/5/INF/24 (IPBES, 2017).

2.2.3 | Carousel session

The aim of this session was to offer a space for participants to suggest actions and actors that could contribute towards achieving their vision for a sustainable future for Mount Kilimanjaro. During the session, the groups moved along the five stops of the carousel (each identified by a flipchart and a facilitator) that represented five levels of governance and action: (a) individual/household, (b) community, (c) regional, (d) national and (e) international. At the start, each group was assigned to one of the five stops of the carousel and invited to propose actions at the corresponding level and identify actors who could be entrusted with these actions. Answers were recorded on the flipchart. After 10 min, the groups moved to the next stop, discussed the results of their predecessors and suggested additional actions. After four changes, all groups had had the opportunity to suggest actions at each of the five levels of governance.

2.2.4 | Research ethics

There was no local research ethics committee that could have approved the proposed protocols. Nevertheless, we took very good care that the rights and well-being of all participants were respected during the whole process and that there was no coercion whatsoever. To ensure that there was no sense of injustice or of preferential treatment and that participation was fully voluntary and free from coercion, participants all received personal invitations in writing with a request for individual confirmations of participation. Information on the purpose of the research, the use of the input, the format and program of the workshop and what the participation involved was provided in the invitation written in English and Swahili and reiterated at the beginning of the workshop during the first plenary session, together with the information that participation was completely voluntary and that withdrawal was possible at any time. Thereby all participants were fully informed of the purpose of the research, how their input would be used and what their participation involved. All participants very much welcomed and orally consented with this information at the inception of the workshop. Accordingly, and as the whole workshop was characterized by a strong spirit of joint interests in the discussed questions as well as a very positive and cordial atmosphere, it did not appear necessary to seek consent in writing. All participants were very pleased by the prospect of contributing to this research and several of them expressed their appreciation for the broad scope of the workshop, which they found especially useful compared with earlier experiences they had with thematically more limited and more sectoral meetings run in other contexts. All participants were also very keen to see the results of this workshop synthesized in one or more scientific publications. They all consented orally with the use of their anonymized responses in one or more scientific publications, again at workshop inception. Anonymization of data from oral discussions was achieved by refraining from recording the identity of the contributors. Moreover, a numeric ID rather than any personal identifying information was included when completing the questionnaires, leaving the data completely anonymous.

To further ensure that the rights and well-being of participants were respected, each discussion group at the workshop designated one local participant as a group leader responsible to facilitate the group discussion and one local note-taker. The designation of both was a participatory process within each group and both the leader and the note-taker were given the opportunity to turn down their responsibilities. By doing so, the workshop organizers ensured that they merely played the role of moderators and that discussions were facilitated on the basis of shared local understandings and cultural values. Group leaders were available to collect and relay any concerns and discomfort of the participants to the organizers, but no such feedback was received. Regular plenaries led and accompanied by the main principal investigator (M.F), by two project coordinators (C.H and A.H) and by two local workshop facilitators (C.A.M and N.M), all with long-term residency and/or experience in the region, served as additional occasions for feedback and further ensured that participants felt comfortable and respected in their rights and values. During none of these sessions was any discomfort expressed by any participant.

2.3 | Data exploration and analysis

2.3.1 | Coding habitat responses

Despite a preliminary group discussion about the habitats of Mount Kilimanjaro (see Section 2.2.1), there was a substantial variation among respondents to the 'habitat' questionnaire in the naming of these habitats. Some organized habitats into highlands, midlands and lowlands, whereas others named habitats with a higher level of detail and made distinctions between land use and land cover (e.g. Chagga home gardens, natural springs and coffee plantations; Table S1 in Supplementary Material S2). To enable comparison among responses, we standardized the habitat classification to seven categories—alpine, forest (including both lowland and montane forest), agroforestry, cropland, urban, freshwater and grassland—and assigned each of the reported habitats to one of these categories using the digitized maps to check for consistency (see Table S1 and Figure S1 in Supplementary Material S2 for correspondence between reported and standardized habitats). Digitized maps (Figure S1 in Supplementary Material S2) were generated using a geographical information system (QGIS Development Team, 2019) based on the printed maps that participants used to delineate their geographic area of expertise (see above). For the figures and tables, we excluded responses for the urban habitat because of the low sample size ($n = 2$).

2.3.2 | Coding ecosystem services into NCP categories

We coded open questions relating to ecosystem services from the 'ecosystem services' questionnaire using IPBES standard terminologies for NCP (Table S2 in Supplementary Material S2, Díaz et al., 2018; Martín-López et al., 2019). We further grouped the 18 NCP into nine NCP clusters (Payne et al., 2020): 'Air and Climate', 'Cultural', 'Energy and Materials', 'Food and Medicine', 'Habitat', 'Livelihoods', 'Pollination and Pest Control', 'Soil and Hazards' and 'Water' (Table S3 in Supplementary Material S2). We introduced an additional 'Livelihoods' category for reported benefits that did not point to a specific NCP, but rather named health or economic benefits in general, including earnings from selling crops and charcoal, and tourism.

2.3.3 | Coding direct and indirect drivers, and recommended actions

We classified responses on direct and indirect drivers of change using the categories adopted by the IPBES Regional Assessment for Europe and Central Asia (IPBES, 2018a), and responses on recommended actions using the Conservation Actions Classification (v2.0) terminologies (Conservation Measures Partnership, 2016). For example, we categorized reported direct drivers such as habitat conversion and degradation and deforestation as 'Land-Use Change' and effects of climate change such as floods, storms and other natural hazards as 'Climate Change' (see Table S4 in Supplementary Material S2). We followed a similar protocol for indirect drivers, for example population growth was categorized as 'Demographic'; corruption, poor land management and enforcement of conservation laws were categorized as 'Institutional' (Table S4 in Supplementary Material S2). We coded recommended actions using the same standard. For example, 'Land/Water management' included suggestions such as 'afforestation', as well as 'integrated water resources management' and 'institutional development' included suggestions such as 'establish environmental groups/committees'.

2.3.4 | Comparison between the groups

We processed and visualized data using the TIDYVERSE package (Wickham et al., 2019) in the R version 3.6.2 (R Core Team, 2019). We used the NETWORKD3 R package (Allaire et al., 2017) to visualize flows between different components of the IPBES framework. We tested whether the responses given for each of the components of the IPBES framework (species diversity and habitats, NCP, direct drivers, indirect drivers and actions) differed between the five stakeholder groups using a permutational multivariate analysis of variance (PERMANOVA; Anderson, 2017). Specifically, we tested whether there were significant differences between (i) the groups and habitats in reported changes in habitat extent over the last 10 years; (ii) the groups in listed NCP; (iii) the groups and NCP in reported changes in access and provision over the last 10 years; (iv) the groups and NCP in responses on how NCP access and provision will change in the next 10 years; (v) the groups and habitats in reported direct drivers and in reported indirect drivers (vi); and (vii) the groups and habitats in what actions are needed to ensure a sustainable future for people and nature in Mount Kilimanjaro. For all questions but (ii) we also tested for interactions between the predictors.

We tested questions (i) and (v–vii) using data from the 'habitat' questionnaire, and questions (ii–iv) on the 'ecosystem services' questionnaire. We implemented PERMANOVA using the *adonis* function with 1,000 runs in the VEGAN R package (Oksanen et al., 2019). To account for multiple comparisons and control for false discovery rate, we adjusted *p*-values using the Benjamini–Hochberg (BH) procedure (Benjamini & Hochberg, 1995). We applied a conservative 5% significance threshold to the BH-adjusted *p*-values, but also report BH-adjusted *p*-values (*p*-value adjusted in Table 1) >0.05 and <0.1 as 'marginally significant' at the 10 % significance threshold.

3 | RESULTS

3.1 | Individual contributions and habitat mapping

The 73 participants filled between one and four forms each (except for one participant who filled in 11 habitat forms), resulting in a total of 143 and 144 responses to the 'habitat' and 'ecosystem services' questionnaires, respectively. Of all the participants, 68 (16 women and 52 men) submitted responses to the 'habitat' questionnaire. This corresponds to 15 participants per group except for the 'Research' and 'Other' groups, where only 14 and 9 participants, respectively, contributed. The same number of participants submitted responses to the 'ecosystem services' questionnaire, which in this case corresponded to 16 participants from the 'Community' and 'Resource' groups, 13 and 14 from the 'Research' and 'Conservation' groups, respectively, and nine from the 'Other' group.

The mapping exercise, during which the participants indicated on a map of Kilimanjaro which areas they were conducting the assessment for (see 'Moderated group discussion' above and Figure S1 in Supplementary Material S2), highlighted key differences. The 'Community' and 'Resources' groups focused on lower elevational areas outside the National Park (i.e. where the residents of Kilimanjaro live), the 'Conservation' and 'Research' groups assessed the whole range of habitats and elevations and the 'Other' group assessed a patchwork of places including the very highest elevations, possibly following tourism hotspots.

TABLE 1 Model results from the permutational analyses of variance (PERMANOVA). We adjusted *p*-values for multiple comparisons using the Benjamini–Hochberg (BH) procedure (Benjamini & Hochberg, 1995)

Variables	Pseudo-*F*	Degrees of freedom	*p*-value	*p*-value adjusted
Species diversity and habitats (IPBES component 1)				
Habitat area ~ stakeholder groups	2.02	4, 104	0.098	0.207
Habitat area ~ habitats	3.93	16, 104	0.002	0.013
Habitat area ~ stakeholder groups × habitats	0.61	6, 104	0.862	0.910
Nature's Contributions to People (IPBES component 2)				
NCP ~ stakeholder groups	3.85	4, 63	<0.001	0.013
NCP (past trend) ~ stakeholder groups	5.47	4, 92	0.002	0.013
NCP (past trend) ~ NCP categories	1.68	8, 92	0.091	0.207
NCP (past trend) ~ stakeholder groups × NCP categories	1.79	20, 92	0.017	0.063
NCP (future trend) ~ stakeholder groups	1.64	4, 92	0.138	0.262
NCP (future trend) ~ NCP categories	0.56	8, 92	0.810	0.905
NCP (future trend) ~ stakeholder groups × NCP categories	0.88	20, 92	0.497	0.674
Direct and Indirect Drivers of Change (IPBES components 4 and 5)				
Direct driver ~ stakeholder groups	1.03	4, 96	0.418	0.662
Direct driver ~ habitats	2.12	6, 96	0.019	0.063
Direct driver ~ stakeholder groups × habitats	1.00	14, 96	0.461	0.674
Indirect driver ~ stakeholder groups	1.28	4, 37	0.258	0.446
Indirect driver ~ habitats	0.48	6, 37	0.910	0.910
Indirect driver ~ stakeholder groups × habitats	0.81	11, 37	0.700	0.831
Actions				
Actions ~ stakeholder groups	1.99	4, 108	0.027	0.073
Actions ~ habitats	1.83	6, 108	0.020	0.063
Actions ~ stakeholder groups × habitats	0.91	16, 108	0.626	0.793

3.2 | Species diversity and habitats (IPBES component 1)

During the group discussion on species, participants identified individual types of organisms at different taxonomic resolution. Altogether participants identified 45 different types of plants, 29 mammal species or groups, nine reptile and amphibian species or groups, eight bird species, three categories of fish, five arthropod taxa, plankton, algae and worms (see Table S5 in Supplementary Material S2). The taxonomic resolution of the listed species varied by taxa, with mammals and birds typically listed at species level, plants to genus and invertebrates at coarser resolution. The 'Community' and 'Conservation' groups listed the highest number of species (37 each), with the former group listing the most plants (23 types) and the latter the most mammals (15 types). As these species lists resulted from group discussions, there is only one data point per group, and we could not test for statistical differences between the groups.

Based on the 'habitat' questionnaire, stakeholder groups did not differ significantly in their assessment of changes in habitat area (Table 1) and the interaction between stakeholder group and habitat was not significant either. However, the reported trends in area differed significantly across habitats. That is, there was a broad consensus among participants that the habitat area was decreasing, but that this decline differed across habitat types (Figure 1 left, Table S6 in Supplementary Material S2). In particular, grassland and freshwater had almost unanimously negative assessments, with over 90% of responses indicating declines in extent and condition (Table S6 in Supplementary Material S2). While a higher proportion of responses indicated positive trends for forest condition than for grassland and freshwater (27% of 37 responses), the predominant view was also of declining forest extent (76%) and condition (68%; Figure S2 in Supplementary Material S2). In the questionnaire, species diversity was only assessed at very coarse taxonomic level (including birds, mammals and trees) and was largely reported to be declining (Figure S3 in Supplementary Material S2).

3.3 | Nature's Contributions to People (IPBES component 2)

Based on the 'ecosystem services' questionnaire and after classifying the NCP of importance into clusters, the most frequently mentioned ones were Water (50% of the 68 participants), Food and Medicine (43%), Livelihoods (26%), Air and Climate (24%) and

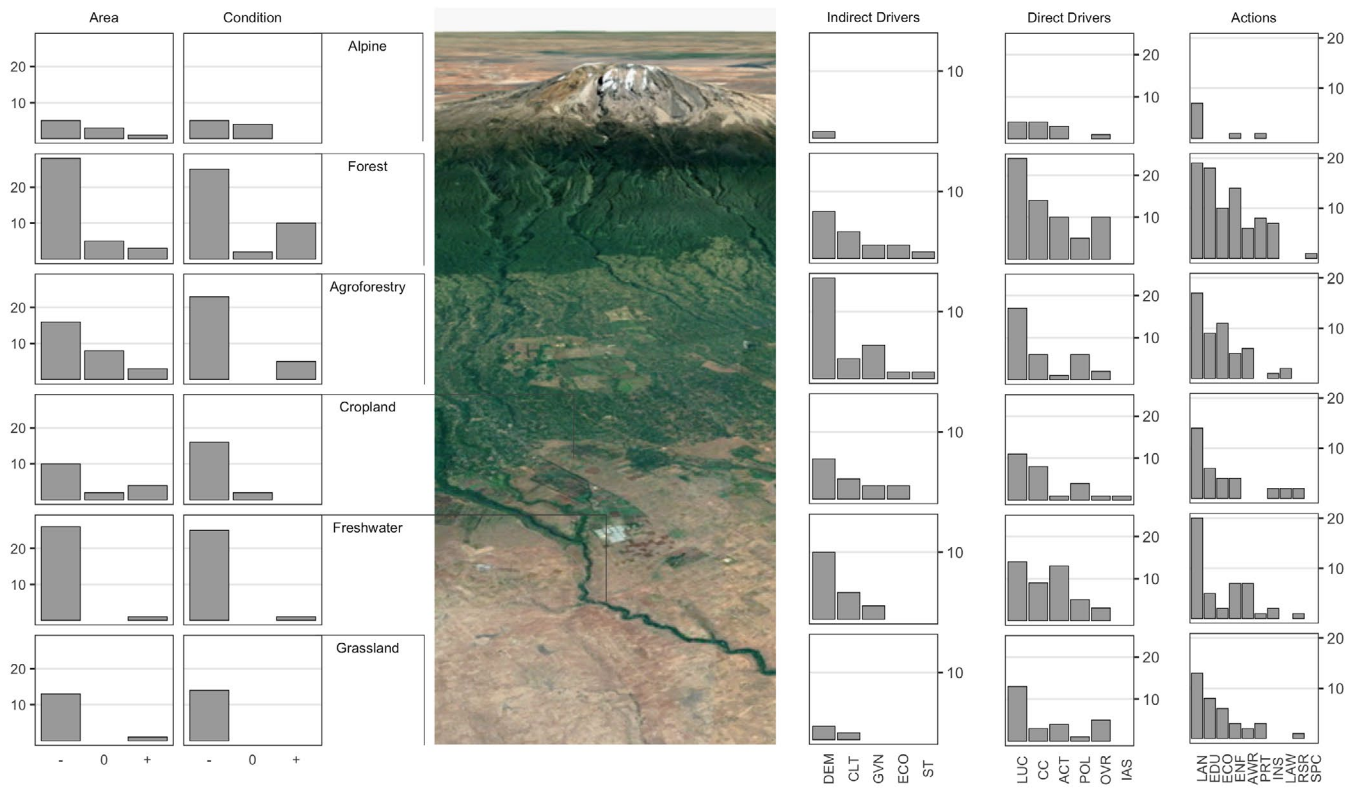

FIGURE 1 Left: trends in area and condition along habitats; right: direct drivers, indirect drivers and recommended actions for each habitat. Height of bars indicates the total number of responses. Direct drivers: ACT, Human Activities; CC, Climate Change; IAS, Invasive Alien Species; LUC, Land-Use Change; OVR, Over-exploitation; POL, Pollution. Indirect drivers: CLT, Cultural; DEM, Demographic; ECO, Economic; GOV, Governance; S&T, Science and Technology. Recommended actions: AWR, Awareness Raising; ECO, Livelihood, Economic and Moral Incentives; EDU, Education & Training; ENF, Law Enforcement and Prosecution; INS, Institutional Development; LAN, Land/ Water Management; LAW, Legal and Policy Frameworks; PRT, Conservation Designation and Planning; RSR, Research and Monitoring; SPC, Species Management

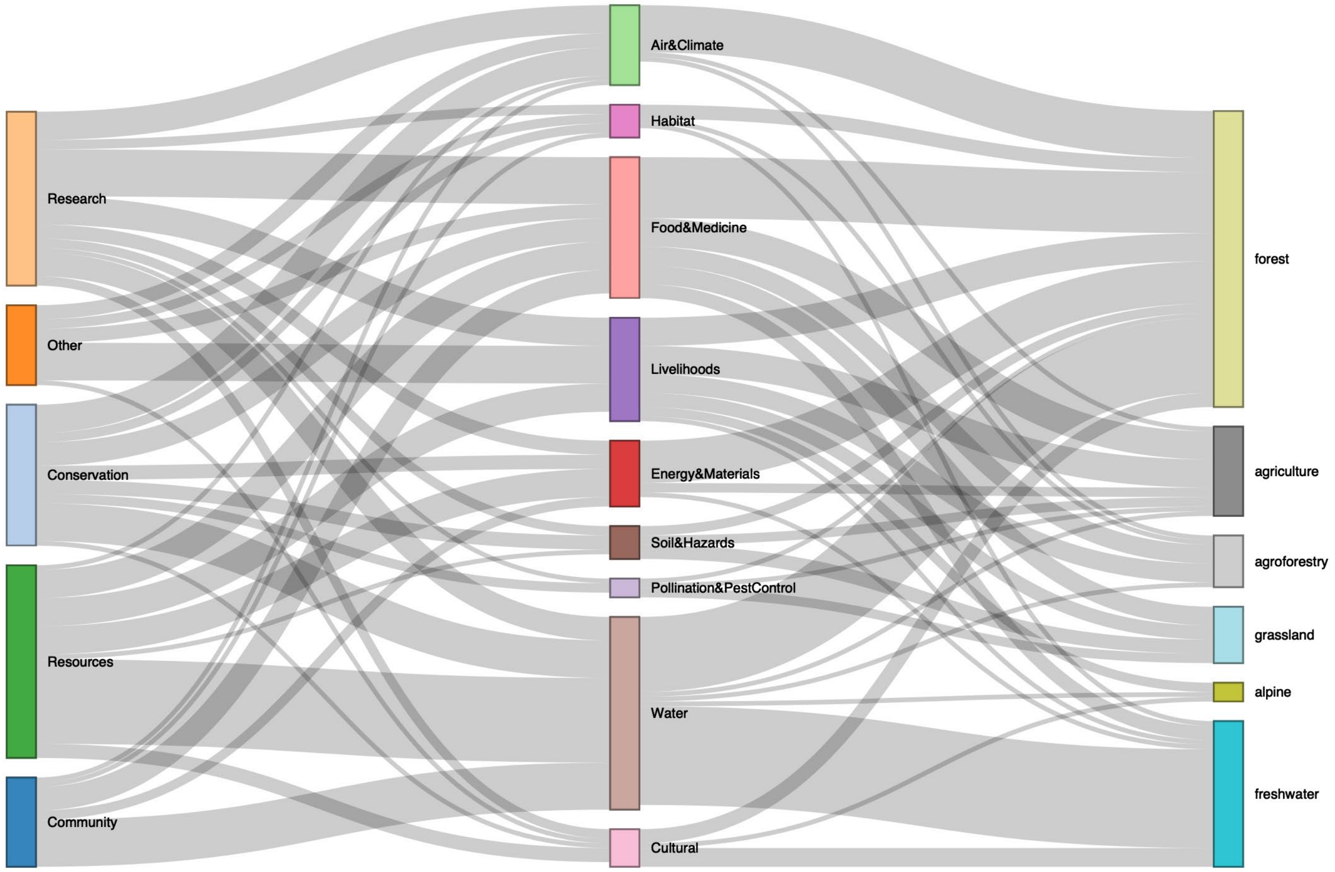

FIGURE 2 The NCP mentioned by different stakeholders in the 'ecosystem services' questionnaire, and the habitats with which the NCP are associated. Links show co-associations between variables in responses (e.g. which NCP was mentioned by which group member, and the habitats with which that NCP was associated), and the width of each link is proportional to the number of responses. The flows are not totally balanced because some respondents associated a particular NCP with multiple habitats (one NCP could be associated with multiple habitats) and because some respondents did not associate a habitat with an NCP. Each source node in the diagram has a different colour to make the links easier to discriminate

Energy and Materials (19%; Figure 2, Table S2 in Supplementary Material S2). The differences in NCP listed between the groups were statistically significant (Table 1). For example, Water was the most frequently cited NCP for the 'Community' (63%, $n = 16$ participants), 'Conservation' (57%, $n = 14$) and 'Resources' (69%, $n = 11$) groups, while Food and Medicine was the most frequently cited NCP by the 'Research' group (77%, $n = 13$) and Livelihoods was the most frequently cited NCP by the 'Other' group (78%, $n = 9$). Forest (45% of 144 responses) and Freshwater (22%) were most frequently listed as important habitats for providing NCP (particularly Water; Figure 2).

Access to these NCP was reported to have declined over the last 10 years by most participants in all categories except Livelihoods (where more participants reported increased than decreased access), reflecting a general trend for material NCP increasing at the expense of non-material NCP (Figure 3). In the 'ecosystem services' questionnaire, participants cited a number of direct and indirect drivers to explain the trends in NCP access over the last 10 years (Figure 4). According to their answers, increased population and competition for resources, combined with climate change, deforestation and forest degradation, has reduced access to Water, Energy and Materials, Food and Medicine, and Air and Climate NCP. However, education and awareness programs, irrigation and infrastructure improvements and tourism have contributed to improving access to Water and Livelihood NCP, countering the general declines (Figure 4). When asked to forecast how access to these NCP might change over the next 10 years, the respondents almost unanimously predicted declines in all NCP categories (Figure 3). The assessment of past trends in NCP provision and access differed significantly across groups (Table 1) but not across NCP categories. The interaction between stakeholder group and NCP category was marginally significant. The assessment of future trends in NCP provision and access did not differ across stakeholder groups and NCP category, and the interaction between them was not significant either.

The 'Community' group listed plant species/genera with value for medicine, food and firewood, and primarily listed domestic and edible animals, while members of the 'Conservation' group listed charismatic megafauna and birds that attract tourists. Participants also discussed the positive and negative benefits provided by some species, such as elephants enhancing tourism livelihoods but raiding crops and threatening humans.

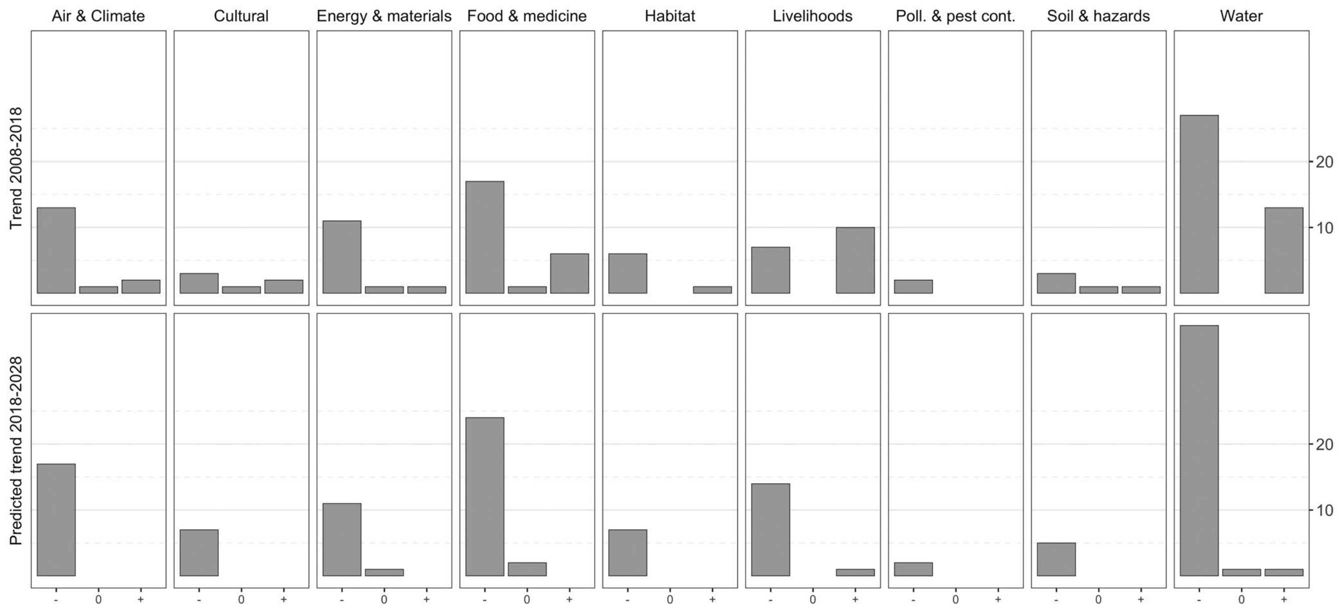

FIGURE 3 Trends in access to key NCP over the years 2008–2018 and prediction for the trend in the years 2018–2028. Ecosystem services listed by respondents in the 'ecosystem services' questionnaire coded into NCP categories following Payne et al. (2020) plus 'Livelihoods' and 'Well-being', 'Energy & mat.', Energy and Materials; 'Poll. & Pest Cont.', Pollution and Pest Control. Height of bars indicates the number of responses

3.4 | Direct and Indirect Drivers of Change (IPBES components 4 and 5)

Based on the 'habitat' questionnaire, participants identified a wide range of direct and indirect drivers for the observed changes in the state of Kilimanjaro's habitats and species diversity (Figure 1). Neither the attribution of direct drivers nor that of indirect drivers differed significantly across stakeholder groups nor habitats and no interaction effect was detected between them (Table 1). The key direct drivers were land-use change (58%, number of questionnaires $n = 143$), climate change (31%), over-exploitation (15%) and pollution (15%), with only one respondent mentioning invasive species. Demographic change was the key indirect driver (29%), followed by cultural changes (10%) and governance (8%). These patterns held across habitats: land-use change was perceived as the main direct driver of change in non-urban habitats, except for the alpine belt, where it was tied with climate change (Figure 1), and demographic change was perceived as the main indirect driver in all non-urban habitats.

3.5 | Actions for the sustainable management of species and habitats on Mount Kilimanjaro and for a sustainable future

Based on the group discussions (Figure 5), there was a general consensus that a happy future for Kilimanjaro depends on water security, a thriving economy and employment, good governance, education, social justice, high environmental quality, food and energy security, sustainable land use and health. A rich diversity of species, sustainable infrastructure and culture were also reported as important elements to a sustainable future, but by fewer stakeholder groups. Further differences between stakeholder groups consisted in the mere formulation of a desirable future and its elements. The 'Community' and 'Conservation' groups, respectively, described it in the following sentences: 'By 2030, Kilimanjaro people by adopting sustainable production and consumption practices, under good governance, enjoy the multiple benefits from a thriving biodiversity and healthy ecosystem which contributes to their social, economic and cultural well-being' and 'By 2030, Kilimanjaro people by adopting sustainable land-use practices under good governance enjoy the multiple benefits from a well-conserved environment and healthy ecosystems, which contribute to their culture, health and well-being; food, water and energy security; employment; education; and wealth creation'. In the 'Resources' group, no overall vision was formulated but a number of quantitative objectives were listed, such as 'an increase in hydropower production by 80%', 'climate-smart agriculture adopted by 50%' or '40% improvement in by-law enforcement'. In the remaining two groups ('Others' and 'Research'), elements were merely listed with more or less detail (e.g. 'health' in 'Research' and 'reduced child mortality' in 'Others').

The options for actions towards a sustainable future identified during the group discussions (Figure S4 in Supplementary Material S2) and the carousel session (Figure 6, Table S7 in Supplementary Material S2) pertained to all levels of governance and were more diverse than the answers collected in the 'habitat' questionnaire (see below). While 'Land/Water Management' types of measures dominated the individual/household level of action, research, education and awareness raising measures as well as institutional, policy and legal measures dominated the other levels of governance, in particular the national and international levels.

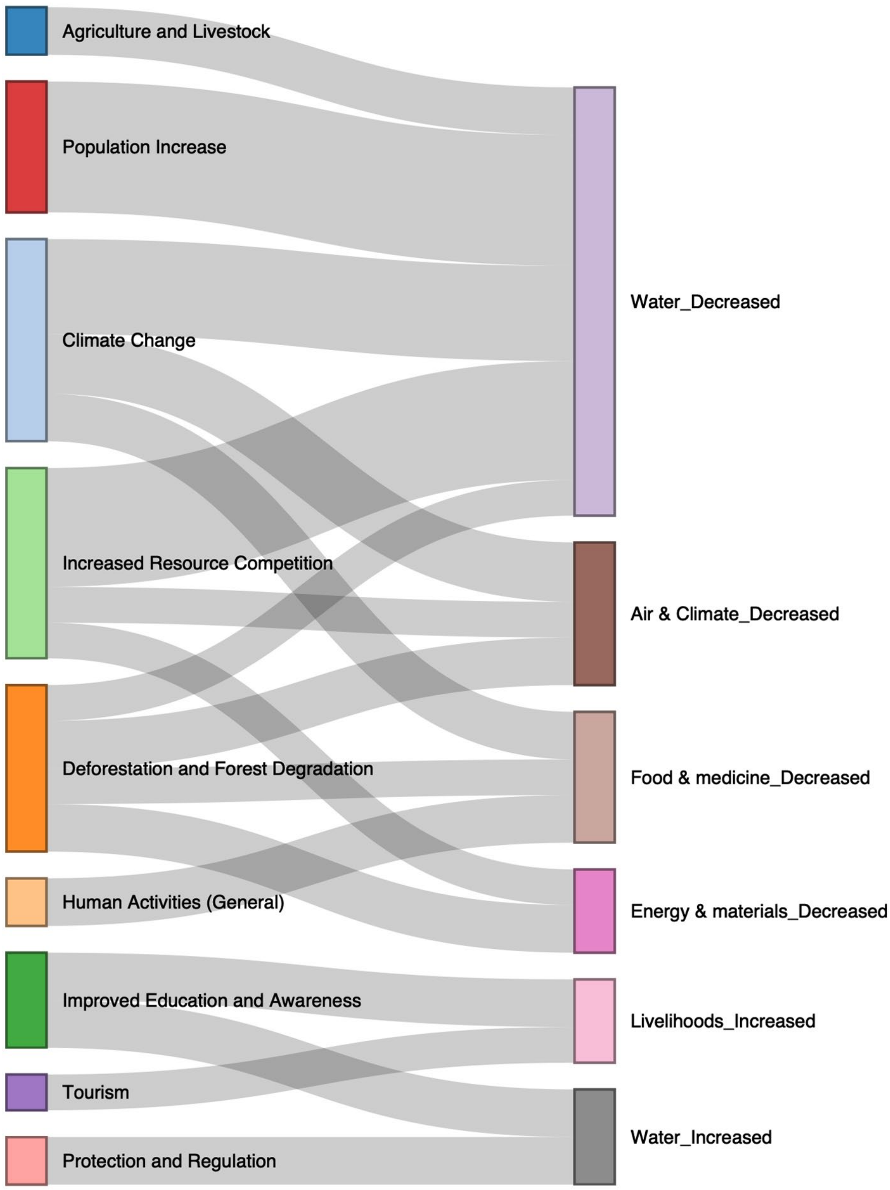

FIGURE 4 Most frequent co-occurrences between trends in coded NCP (cf. Figure 3) and their drivers (both direct and indirect), using a different coding of drivers from Figure 7. Only co-occurrences with more than two responses are displayed. Each source node in the diagram has a different colour to make the links easier to discriminate

Differences in identified actions to conserve and restore species diversity and NCP in the 'habitat' questionnaire across stakeholder groups were marginally significant (Table 1; i.e. significant at the 10% threshold but not the 5% threshold) after adjusting for multiple comparisons. There were no significant differences across habitat and no significant interaction between habitats and stakeholder groups either (Figure S4 in Supplementary Material S2). The actions most frequently reported in these forms were in the Land/Water Management category (64% of 143 responses), which included afforestation, integrated water resources management and reforming agricultural practices. Education on conservation issues and less environmentally harmful agricultural practices was the second most frequently mentioned action category (32%). Economic incentives, including alternative income sources, development of livelihoods such as beekeeping and subsidies for cleaner fuel use, and enforcement of existing environmental regulations were both mentioned by 24% of respondents.

3.6 | Synthesis

After collecting results separately for different components of the IPBES framework, we linked responses about indirect drivers to responses about direct drivers, trends in habitats and actions using data from the 'habitat' questionnaire (Figure 7). Using the 'ecosystem services' questionnaire, we linked responses about drivers and responses about NCP trends (Figure 4). This revealed an overall picture in which demographic pressures of increased

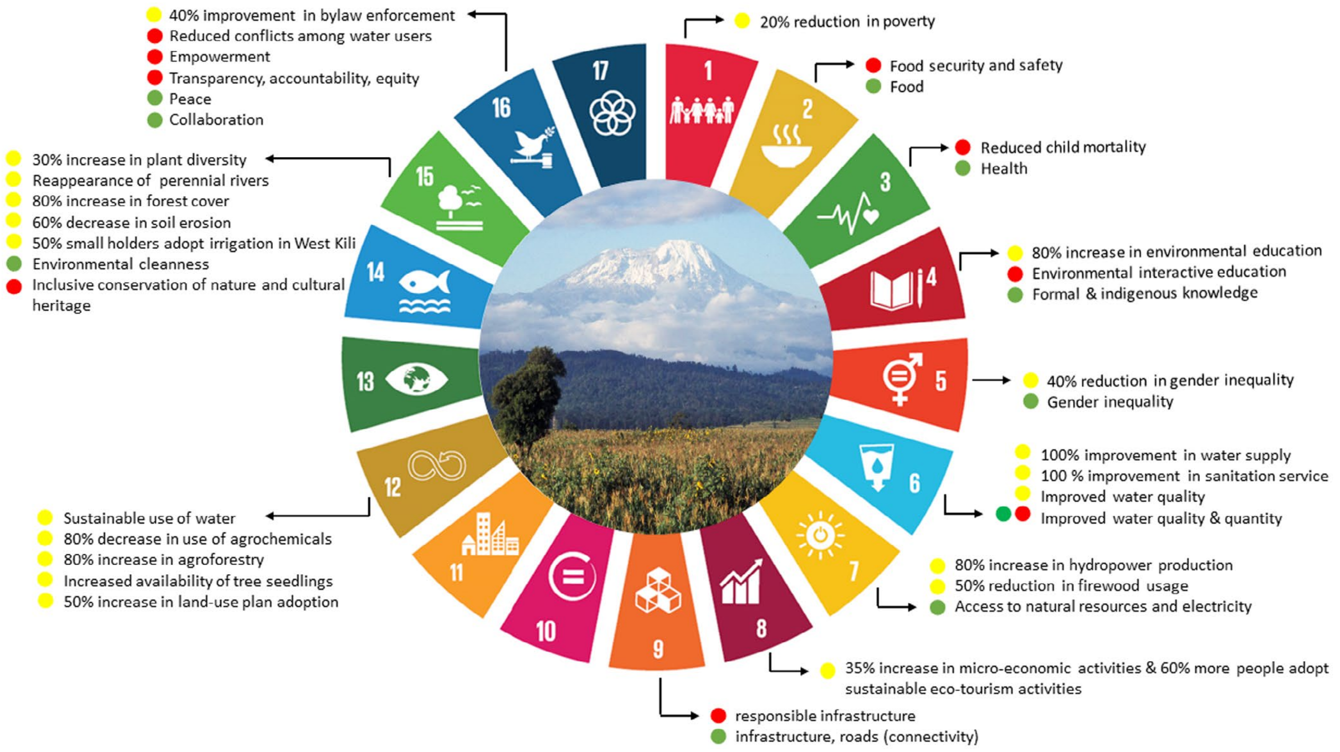

FIGURE 5 Elements of stakeholders' vision for a sustainable future for Mount Kilimanjaro and its inhabitants based on group discussions (yellow = 'Resources', red = 'Other, green = 'Research') and mapped onto the Sustainable Development Goals

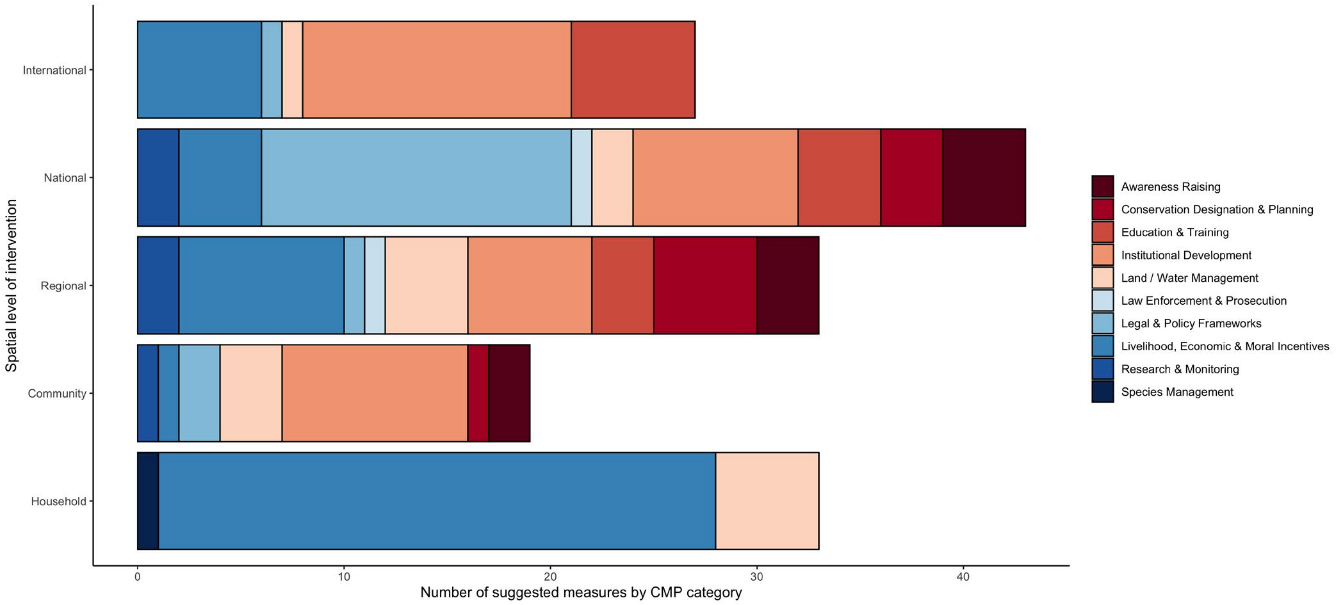

FIGURE 6 Number of different measures towards a sustainable future for people and nature on Mount Kilimanjaro as proposed by all participants during the carousel session and grouped by Conservation Measures Partnership (CMP) categories

population and demand for resources largely underpin the pressures for land-use change, over-exploitation (including over-grazing by livestock) and pollution. The demographic pressures are exacerbated by alienation from traditional cultural practices, weak governance and economic pressures. Land-use change in particular drove decreases in the extent of forests, grasslands and freshwater habitats (Figure 1). These trends were exacerbated by climate change, which is also the main driver of alpine habitat loss (Figure 7). The pressures of land-use change and climate change on forests and freshwater systems undermined the provision of Water, Livelihoods, Food and Medicine and Air and Climate. That is, pressures on the most important habitats for NCP provision (Figure 3) undermined the provision of NCP that are important for supporting the growing population on the mountain (Figures 3 and

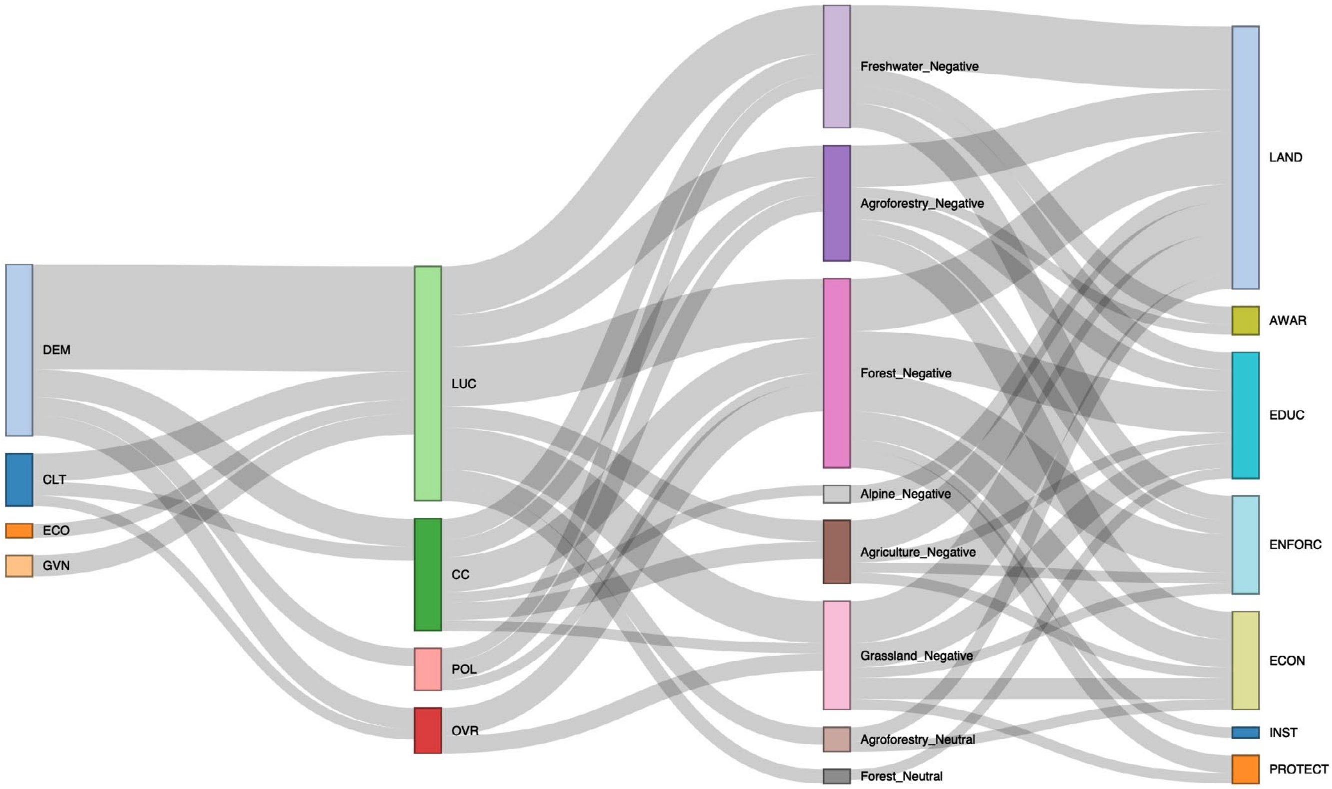

FIGURE 7 The key indirect drivers, direct drivers, changes in habitat area within habitats and suggested actions mentioned by different stakeholders in the 'habitat' questionnaire. Links show co-associations between pairs of variables in responses (which indirect driver was associated with which direct driver, which direct driver was associated with which habitat area trend and which habitat trend was associated with which suggested action), and the width of each link is proportional to the number of responses. The flows are not totally balanced because one trend in habitat area could be associated with multiple (or no) drivers and recommended actions. Only links with more than five responses are displayed. Each source node in the diagram has a different colour to make the links easier to discriminate

4). However, enhanced education and awareness about resource management and irrigation programs countered negative trends in water provision and tourism improved livelihoods (Figure 4). Given their reported success in improving access to NCP, land-water management, enhanced education and awareness and economic incentives featured prominently in suggested actions to improve the stewardship of Mount Kilimanjaro's habitats and the NCP they support (Figure 6). Overall, stakeholder groups differed significantly in their assessment of the NCP supported by different habitats and NCP access and provision trends over the last 10 years. Stakeholder groups differed in recommended actions at the 10% significance threshold but not the 5% significance threshold. They did not differ significantly in their assessment of direct and indirect drivers of changes, projected changes in NCPs and in their assessment of trends in the habitat extent.

4 | DISCUSSION

The IPBES framework served as an effective tool to structure the recording of individual and group perceptions of the challenges and opportunities for living a good life in harmony with nature on and around Mount Kilimanjaro. These perceptions represent an important source and body of knowledge that enrich quantitative findings and current discourse, and the use of the IPBES framework for their recording can facilitate the weaving of knowledge held by stakeholders and researchers. This first successful application of the whole IPBES framework in a workshop setting on the relationship between nature and people at Mount Kilimanjaro provides an encouraging illustration of its applicability in a participatory context.

4.1 | Stakeholder perceptions of the relationship between nature and people

4.1.1 | Species diversity and habitats (IPBES component 1)

Participants recognized the unique diversity of species of Mount Kilimanjaro and the importance of individual species for their livelihood and well-being. They generally agreed that mammal, bird and tree diversity is decreasing and that all non-urban habitats of Mount Kilimanjaro are degrading. This general agreement echoed accumulating evidence for a decline in species diversity and in the extent of natural habitats on Mount Kilimanjaro (e.g. Hemp, 2006c; Hemp & Hemp, 2018; Kitalyi et al., 2013; Lyaruu, 2002; Misana et al., 2003;

Newark, 1991; Peters et al., 2019; Soini, 2006; Stephen, 2015) and across East African mountains (IPBES, 2018b; Payne et al., 2020). The negative trends in all non-urban habitats of Mount Kilimanjaro (Figure 1 left) call for conservation measures along the entire elevational gradient of the mountain, including protected areas.

4.1.2 | Nature's Contributions to People (IPBES component 2)

Participants recognized the importance of the mountain in supporting various NCP, particularly material ones (MEA, 2005). These results support the growing body of literature on the importance of mountains in supporting vital NCP (Grêt-Regamey et al., 2012; Martín-López et al., 2019; Payne et al., 2020) and existing evidence for the particularly high importance of material ones in East Africa (Wangai et al., 2016). The recurrent mention of water as a key NCP (Figure 2) speaks to the importance of water for local populations (Hemp, 2005; Said et al., 2019; Sébastien, 2010), which is the case also in other East African mountain regions such as Mount Kenya (Dell'Angelo et al., 2016) and to the long-persisting challenges associated with its management (e.g. Lein, 2004). It further contextualizes available evidence for increasing water resource conflicts due to growing demand as well as decreasing access and availability (Said et al., 2019). The importance given to food and energy (Figure 2) also speaks to existing evidence for the role of Mount Kilimanjaro as a primary source of food, fuel and building materials for people of north-central Tanzania (Bär et al., 2017; Sébastien, 2010). The general consensus among workshop participants that access to NCP had declined over the last decade and that these trends are likely to worsen in the future (Figure 3) also accorded with existing literature reporting declines in NCP provision in the mountains of East Africa (IPBES, 2018b; Payne et al., 2020). The only exception was the perceived improvement in the so-called livelihood NCP (Figure 3), which consisted of contributions from nature to material well-being and the economy that could not be strictly attributed to other NCP categories. Differences in stakeholder perceptions about the importance of individual NCP are also in line with available studies describing how geographic, socio-economic and cultural factors, life experiences, as well as the use or non-use of particular resources and areas shape people's valuation of NCP, species and the environment (Cuni-Sanchez et al., 2019; Ndayizeye et al., 2020). Such differences can also serve to explain differences in the actions that participants proposed or prioritized for achieving their vision for a sustainable future for Mount Kilimanjaro.

4.1.3 | Direct and Indirect drivers of change (IPBES components 4 and 5)

Both the recurrent references to land-use and climate changes as direct drivers and to population growth as indirect driver (Figures 1 right and 4) were in line with previous studies on Mount Kilimanjaro (Noe, 2014; Soini, 2005a). Nuances given to the importance of land use and climate along the elevational gradient of Mount Kilimanjaro further confirm accumulating evidence for a higher importance of land-use change below the tree line (e.g. Payne et al., 2020).

Based on our analysis, land-use change, and in particular the conversion of forests and grasslands into cropland in response to the shortage of arable land, is largely a result of growing demographic pressure and an increasing demand for agricultural products. Economic factors represent another important driver frequently mentioned in the literature. These factors include the timber and charcoal market responsible for much of the ongoing legal and illegal logging activities as well as the large inter-annual variation in coffee prices, which results in a transition towards the cultivation of alternative crops (e.g. maize, beans and vegetables) and horticulture (Misana et al., 2003; Soini, 2005b). Societal factors in turn, including the overall decrease in fertility rates, increased empowerment of women (Larsen & Hollos, 2003) and an increase in the marketable knowledge and skills of local populations (Soini, 2005a; Soini, 2005b), may contribute to counteracting ongoing trends. Yet, population growth in the Kilimanjaro region remains a major driver towards land-use change and causes subdivision of land into fragments that are both too small to support a family (Soini, 2002) and too numerous to allow any further expansion (Misana et al., 2003). The conversion of natural habitats into the croplands needed to feed a growing population (Tilman et al., 2017) is a global problem and one of two broad responses to demographic and economic pressures, the second being an increase in the intensity of production per unit area (Phalan, 2018). Pursuing the former has led to alarming declines in biodiversity world-wide (Chaplin-Kramer et al., 2015; Dudley & Alexander, 2017), including in the Kilimanjaro region (Hemp & Hemp, 2018). Unless food production is outsourced to areas outside Kilimanjaro, which in turn outsources environmental problems, the sparing of Mount Kilimanjaro's biodiverse forests and grasslands will require the sustainable intensification of cropland agriculture and agroforestry systems, combined with socially acceptable land management measures (Phalan, 2018; Tilman et al., 2017).

4.1.4 | Options for decision-making and action towards a more sustainable future for the region

In line with recent results for all of Northern Tanzania (Kariuki et al., 2021), desirable futures for the participants of our workshop were those with high environmental integrity and stable livelihoods (thriving economy, high employment rates, water, energy and food security). Among the most frequently reported actions, both afforestation and integrated water resource management echo the importance that most participants attributed to water provision and their focus on forest and freshwater habitats. The importance of reforestation is in line with priorities set by other stakeholders in northern Tanzania (Kariuki et al., 2021). The insistence on water resource management, in turn, suggests that past water management efforts in the Pangani River Basin (IUCN, 2003) and recent recommendations to account for the welfare of local communities in watershed conservation and water governance along the Basin (Kabogo et al., 2017; Lalika et al., 2015) have not yet been fully successful. Stakeholder perceptions as collected here represent valuable information to support the complex and iterative process of forming coalitions and including participation of all stakeholders in enacting Tanzania's legal and institutional frameworks related to freshwater resources management. In the face of the growing hydrological risks, to which Mount Kilimanjaro and its populations are exposed, water and forest management are of utmost importance (Sébastien, 2010). However, the importance given to water across stakeholder groups, and in particular among the community representatives, supports recommendations to develop solutions to the water problems that are not mainly technological but mostly of social nature and based on agreed social rules and organization (e.g. social organization of access to irrigation canals; Sébastien, 2010). It further supports recommendations to encourage development projects that focus not exclusively on water as a natural capital but also as a social and cultural capital (Sébastien, 2010). Increased societal participation in the formulation of management schemes also appears important for addressing long-term forest conservation and use (Kijazi & Kant, 2011a).

Further actions proposed towards a more sustainable future were improved education on conservation issues and the adoption of sustainable agricultural practices. These results resonate with existing literature on the lack of knowledge about biodiversity-friendly agricultural practices (e.g. use of natural enemies for pest control, Mkenda et al., 2020). It equally resonates with evidence for limited access to information about sustainable practices (Mkenda et al., 2020) and the benefits of sustainable resource utilization and management (Noe, 2014). Evidence for the importance of cultural and socio-economic factors, including economic incentives, in determining the adoption of conservation measures across various segments of society and various stakeholders (e.g. Durrant, 2004; Kijazi & Kant, 2011b; Kilima et al., 2014; Noe, 2014) further points to the need for societal participation.

The actions participants suggested in written were largely oriented towards the practical management of natural resources with little references to land reform- and land rights-based measures. A possible explanation is the absence among the participants of higher level policymakers and decision-makers who might have suggested different actions and options. Additionally, options for interventions were proposed in response to very general questions pertaining to drivers and potential actions, as opposed to detailed questions pertaining to specific intervention levels. Accordingly, answers likely speak primarily to participants' first-hand experience. Answers provided during group discussions and the carousel session, in turn, addressed a larger set of entry points across policy and practice (see Figures 5 and 7 and Table S7 in Supplementary Material S2) and a number of different actors.

4.1.5 | Insights from novel data

In most cases, the stakeholders in our study confirmed existing literature and quantitative evidence on the state of and trends in species and habitats around Mount Kilimanjaro. They also confirmed perceptions gathered during group discussions with other stakeholder groups in the region (e.g. Kariuki et al., 2021). However, in line with differences among stakeholders and ethnic groups in other Central and East African contexts such as Burundi and the Democratic Republic of Congo (Cuni-Sanchez et al., 2019; Ndayizeye et al., 2020), we detected differences between stakeholder groups. Specifically, we found statistical differences at the 5% significance level across the questionnaire responses in the NCP listed, in NCP access and provision trends over the past 10 years, and among habitats in changes in habitat area over the last 10 years. At the 10% significance level, we also detected significant differences between the groups in recommended actions to conserve and restore species diversity and NCP. The choice of significance threshold is an arbitrary one, as there is always a trade-off between detecting false positive effects and failing to detect true positive effects. However, despite the small sample sizes and low power of the analysis, seven of 19 tests were significant at the 5% threshold for unadjusted p-values, and three of 19 were significant at the 5% threshold for BH-adjusted p-values, which is more than the ~one in 19 that would be expected by chance. Through group discussions and the carousel session, we also found qualitative differences in the actors responsible for implementing individual measures, as well as in the elements and the formulation of desirable futures.

These differences point to the necessity of adopting different discourses, entry points and levers for different stakeholder communities in order to collectively identify and ultimately achieve common sustainability objectives that align with national (e.g. the Tanzanian national development blueprint 'Vision 2025') and global agendas. Yet, developing narratives of stakeholder visions that could guide the short- and long-term planning and prioritization of management actions would require the collection of additional data and the adoption of additional participatory approaches for the exploration of alternative futures (Capitani et al., 2016; Thorn et al., 2020; Thorn et al., 2021). Whereas the challenges of species and habitat conservation are typically illustrated with the example of protected areas (Caro et al., 2009), which points to tensions between global conservation objectives and local societal and economic needs, our results highlight the importance of resolving discrepancies and aligning visions among local stakeholders at subnational scale.

4.2 | The IPBES framework in participatory workshops

Participatory workshops and focused group discussions effectively serve to make stakeholders the focal point of sustainability research and action. This is essential in reconnecting top-down management and policy mechanisms with grassroot knowledge and needs and in identifying socially acceptable pathways towards sustainability that are owned and endorsed locally across stakeholder groups (Capitani et al., 2016; Orenstein & Groner, 2014). Accordingly, land-use and land-cover change scenarios for northern Tanzania based on stakeholder discussions revealed conflicting objectives of wildlife conservation and agricultural expansion and highlighted the need for an integration of local governance in sustainable landscape management (Kariuki et al., 2021). Putting stakeholders at the centre of research is further essential in validating the results of strictly ecological approaches to biodiversity and ecosystem service assessments and overcoming their limitations (Orenstein & Groner, 2014).

The IPBES framework served as a useful tool to guide the recording of perceptions on the relationship between nature and people. As such, and although it has not necessarily served to unveil fundamentally novel narratives and presents limitations for dealing with contrasting knowledge forms (Löfmarck & Lidskog, 2017), it has been useful in achieving a level of standardization and comparability between answers and stakeholder groups that is essential for a balanced understanding of individual visions and the detection of differences between the groups. Regular group discussions, in turn, were helpful in establishing a common understanding of the framework's elements. Yet, the use of specific terminologies and concepts, such as that of ecosystem services, represents a challenge that we could not fully address, that undermines the achievement of shared understandings between stakeholders with different perceptions of and relationships to nature (e.g. Lamarque et al., 2011) and that the language barrier amplified. For example, depending on the language, the word 'nature' can implicitly include humans, exclude humans or have a spiritual component, as is the case in the Swahili term '*Asili*' (Coscieme et al., 2020). Targeted efforts to establish a mutual understanding of individual concepts can help improve the results and ultimately save time spent interpreting ambiguous answers after the workshop. However, the cultural and emotional experiences behind 'experiential knowledge' and the social dimensions associated with 'value-based knowledge' (Glicken, 2000) remain inherent to people's vocabulary and perceptions and are important for interpretation. Moreover, the language of science can generate a feeling of exclusion among non-scientific participants (Glicken, 2000). These challenges highlight the importance of workshop facilitation (Reed, 2008).

As the adoption of standardized categories (e.g. of drivers and NCP) can hinder the recording of interesting socio-cultural nuances and worldviews, we collected most information with open questions, applied the standardized categories during data analysis and included some of the nuances in the discussion. Yet, the level of nuances achieved during the group discussions (see Supplementary Material S2) and the difficulties encountered when classifying actions reveal the challenges associated with the use of questionnaires and standardized frameworks to collect and analyse perceptions across actors with very different socio-cultural backgrounds, expertise and experience. The observation that participants did not spontaneously distinguish between direct and indirect drivers, nor between NCP and human well-being, further highlights the challenge of translating qualitative storylines into quantitative information (Walz et al., 2007) and of codifying stakeholder knowledge that is often varied and sometimes conflicting (Reed et al., 2013). It confirms that standardized categories do not necessarily correspond to individual perceptions or worldviews and are mostly conceptually useful. Other participatory approaches, ranging from participatory drawing (e.g. O'Donovan et al., 2020) and GIS (Brown & Fagerholm, 2015; McCall, 2003) to participatory scenario development (e.g. Capitani et al., 2016) and planning (Thorn et al., 2020; Thorn et al., 2021), could have elicited different understandings and visions, in particular in terms of possible futures (Thorn et al., 2020). Moreover, other conceptualizations of mountain social–ecological systems (e.g. the conceptual model proposed by Klein et al. (2019)), and other frameworks of analysis (see Binder et al., 2013 for a comparative analysis) might have revealed different perceptions, concerns and priorities. These conceptualizations and frameworks could also have given more emphasis to specific dimensions and elements such as governance, sectors and actors. The IPBES framework presents the advantage that its application facilitates comparisons with recent assessments of the state of species and habitats and the relationship between nature and people (Martín-López et al., 2019; Payne et al., 2020). A combination of approaches including the use of the IPBES framework together with different participatory approaches to knowledge mobilisation could prove particularly effective.

A challenge in applying participatory approaches to the generation of experiential or value-based knowledge resides in stakeholder representation and the identification of social groups likely to differ in their understandings, perceptions and representations (Caballero-Serrano et al., 2017). For this workshop, we specifically selected participants covering a broad range of sectors and local communities and subsequently grouped them into stakeholder groups but did not seek to constitute representative samples by gender and age group. Thus, some caution is warranted when interpreting both the absence of differences between stakeholders in their assessments of species diversity, NCP and drivers and the detected differences in the suggested actions towards long-term sustainability. Future analyses seeking to more explicitly explore the perceptions of stakeholder groups, as opposed to individual perceptions, will benefit from a more systematic stakeholder mapping (Glicken, 2000). Moreover, a number of prerequisites need to be met to ensure engagement and to manage communication, including an understanding of the potential social dynamics at play and a clear agreement among stakeholders on the objectives for the participatory process at the onset (Reed, 2008).

4.3 | Implications

The message from the stakeholders was clear. Land-use and climate changes threaten Mount Kilimanjaro's unique species diversity, and its contributions to people (NCP). Participants broadly identified improved natural resource management as important to achieve a sustainable future for Mount Kilimanjaro's people and its nature. The overall consensus across stakeholder groups of the problems facing Mount Kilimanjaro's species diversity and habitats and of possible solutions is encouraging as it suggests broad support for the conservation actions that need to be taken. Looking ahead, we recognize the need to further our understanding of the nuanced ways in which people value nature and its contributions.

We further recognize the need to better understand the implications of their perceptions and experiences for the formulation, implementation and adoption of just and equitable pathways towards the long-term sustainability of the Mount Kilimanjaro social–ecological system. Moreover, in the light of our experience, we encourage the systematic adoption of participatory methods based on a mutual understanding of human-environmental interactions for the co-design of practical solutions with a large variety of actors and knowledge holders, for promoting social learning and for ultimately achieving common objectives. By systematically investigating the role of nature for human well-being in the Kilimanjaro social–ecological system, the recently established Kili-SES project will provide additional scientific basis for political and societal decision-making, thereby facilitating transformation towards sustainable relationships between nature and people at Mount Kilimanjaro.

5 | CONCLUSION

Despite the challenges associated with concepts and terminologies and with achieving a shared understanding across various stakeholder groups, we successfully tackled the many dimensions of the IPBES framework within only 3 days, and participants were favourably disposed and eager to engage in a discussion addressing different aspects of the social–ecological system of Mount Kilimanjaro. Based on this experience we propose that the IPBES framework can be effectively adopted for the mobilization of non-academic knowledge on the relationship between nature and people and that it represents a useful methodological tool to scale up the participatory assessments of local perspectives on social–ecological systems. Future applications of this framework in participatory assessments of social–ecological systems will further show its potential in eliciting stakeholder perceptions and mobilizing the non-academic knowledge needed for the co-design of pathways towards a sustainable future.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHORS' CONTRIBUTIONS

M.F., M.A.S. and D.U. conceived the workshop and developed the methodology; M.F., M.A.S., D.U., C.A.M., A.T.-M.R., R.M.-V. and N.P.M. collected the data; C.A.M., G.W.P. and M.A.S. performed data curation and analysis; C.A.M., D.U., M.A.S. and G.W.P. led the writing process, and all authors edited the manuscript draft and approved its publication.

DATA AVAILABILITY STATEMENT

Data are available on Zenodo at https://doi.org/10.5281/zenodo.5846443. R code used for the statistical analyses and to produce the figures is available on GitHub and integrated in Zenodo at https://doi.org/10.5281/zenodo.5879758.

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