Environmental Management (2018) 62:858–876
https://doi.org/10.1007/s00267-018-1093-7

People-Centered and Ecosystem-Based Knowledge Co-Production to Promote Proactive Biodiversity Conservation and Sustainable Development in Namibia

Axel Schick[1] · Christina Sandig[1] · Anja Krause[1] · Peter R. Hobson[2] · Stefan Porembski[3] · Pierre L. Ibisch[1]

Received: 25 December 2017 / Accepted: 6 August 2018 / Published online: 17 August 2018

Abstract

Growing levels of uncertainty and vulnerability generated by land use conversion and climate change set demands on local communities and national institutions to build synergies between the diverse array of knowledge systems in order to provide policy makers and practitioners with the best available information to decide what urgent actions must be taken. Science policy arenas and agreements such as the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) and the Convention on Biological Diversity (CBD) recognize the importance of different types of knowledge and the need for broad stakeholder involvement, yet the use of indigenous and local knowledge (ILK) in environmental decision-making processes is still underdeveloped. This study involved working with local stakeholders, using the MARISCO method (adaptive MAnagement of vulnerability and RISks at COnservation sites) to carry out a systematic situation analysis of the existing socioenvironmental conditions. The assessments were conducted in the Kavango East Region in northern Namibia with the participation of inhabitants of the Khaudum North Complex, a protected area network covering wooded savannahs belonging to the Northern Kalahari sandveld. General outcomes of the assessments and evaluations made by the local stakeholders concerning the most critical drivers of degradation of the ecosystems appeared to support existing scientific knowledge of the study area, demonstrating that community-based assessments can provide valuable information about socioecological systems where scientific data are scarce. The findings of this study also highlight the importance of power dynamics for the implementation of participatory processes and the interpretation of their outcomes.

Keywords Conservation · Ecosystem-based · Community-based conservation · ILK · MARISCO · Namibia

Introduction

In the face of unprecedented global change driving and accelerating the degradation of ecosystems and the loss of biodiversity, it is important to provide decision and policy makers with the best available knowledge to decide what actions must be taken in order to mitigate the ongoing ecological crisis and to adapt to unavoidable future change as much as possible (Thaman et al. 2013). There is now a general consensus that certain indigenous and local knowledge (ILK) systems can be pivotal in resolving complex socioenvironmental problems as they are rich sources of context and site-specific information, and provide knowledge about conditions, change, trajectories, and causal relationships relevant to the sustainable governance of ecosystems and biodiversity (Tengö et al. 2013). ILK refers to the cumulative body of knowledge, practice, and belief concerning the relationships of living beings

Electronic supplementary material The online version of this article (https://doi.org/10.1007/s00267-018-1093-7) contains supplementary material, which is available to authorized users.

✉ Axel Schick
axel.schick@hnee.de

[1] Centre for Econics and Ecosystem Management, Faculty of Forest and Environment, Eberswalde University for Sustainable Development, Alfred-Moeller-Str.1, 16225 Eberswalde, Germany

[2] Centre for Econics and Ecosystem Management, Writtle School of Sustainable Environments, Chelmsford Essex CM1 3RR, UK

[3] Institut für Biowissenschaften, Allgemeine und Spezielle Botanik, Botanischer Garten, Faculty of Mathematics and Natural Sciences, University of Rostock, Wismarsche Str. 8, 18051 Rostock, Germany

(including humans) to one another and to the physical environment, and characterizes rural, often remote societies deeply immersed and dependent on the services of local ecosystems (Berkes 1999; Kimmerer 2002). ILK is materially and spiritually embedded within its landscape and handed down through generations by cultural transmission. The personal relationship and long-term perspective make ILK complementary to scientific observations, mostly made by a small group of professionals, often representing synchronic data or simultaneous observations from a wide range of sites.

Studies around the globe have demonstrated the importance of ILK but also some of the challenges that arise when different knowledge systems come together (Reid et al. 2006; Laidler 2006; Santos de Aquino et al. 2007; Roturier and Roué 2009; Raymond et al. 2010; Mercer et al. 2012; Jiao et al. 2012; Hill et al. 2013; Nel et al. 2016). The Arctic region has been important in this regard, where small research projects have grown into longtime collaborations (e.g. the Arctic Borderlands Ecological Knowledge Society or the Whitefeather Forest Research Co-operative) and large-scale assessments such as the Arctic Climate Impact Assessment (ACIA 2005). These studies have highlighted the ontological and epistemological, as well as social, institutional, and political challenges that arise when different knowledge systems collaborate, and have also helped to overcome conventional approaches of knowledge integration, and to move forward towards the co-production of knowledge (Armitage et al. 2011). Armitage et al. (2011) define knowledge co-production as “the collaborative process of bringing a diversity of knowledge sources and types together to address a defined problem and to build an integrated or system-oriented understanding of that problem”.

Science policy arenas and agreements such as the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) and the Convention on Biological Diversity (CBD) acknowledge the importance of ILK in their work and explicitly support a diversity of knowledge systems to inform international biodiversity assessments and decision making (Díaz et al. 2015). A variety of methods are available to elicit ILK from groups of stakeholders (Huntington 2000; Aswani and Lauer 2006; Leite and Gasalla 2013; Reyes-Garcia et al. 2013), but practitioners and resource managers worldwide still hesitate to involve indigenous and local communities into decision-making processes. Part of this reservation stems from the western scientific worldviews that still prevail both at levels of decision making and in management, where other forms of knowledges are deemed incredible, inconsistent, or beliefs without any validity (Agrawal 1995; Huntington 2000; Berkes 2009; Tengö et al. 2014). In instances where practitioners decide to involve ILK holders into decision-making processes, they face a number of challenges, including barriers related to trust, language, culture, worldviews, and experience, as well as the substantial investments of both time and funds for logistics, interpreters, preparation, and participation (Tengö et al. 2017).

In recent years, greater efforts have been made to involve indigenous and local communities in decision-making processes but not without attracting criticism from certain quarters (Cooke and Kothari 2001; Mohan and Hickey 2005). For a group of scholars, conservation interventions of governments, nongovernmental organizations (NGOs), and scientists have too often been little other than means of co-optation to impose their green agendas on local communities against their interests (Escobar 1998; Selfa and Endter-Wada 2008). This criticism is in line with a debate within participatory studies, which questions the legitimacy of participatory processes in general, because “even ‘well-intended’ processes tend to be dominated by the worldviews of external participation ‘experts’ who employ imported approaches that inevitably impose particular norms and practices upon the participating subjects” (Kothari 2001).

There is the added problem of modern popular misperceptions about indigenous and local communities that they are naturally vulnerable in their ignorance and thus helpless in the face of changing circumstances. More nuanced views apprehend participatory processes as social arenas where external and local actors engage and interact in struggles over resources, knowledge, and influence (Nuijten 2005). These interactions rarely take place on an equal footing, as powerful actors are likely to use their assets and advantages to ensure their interests are met. Consequently, recent studies have focused on the power of inequalities that come into play during participatory processes, within communities, as well as between communities and governmental institutions and scientists (Staddon et al. 2015; Tschakert et al. 2016).

In this article, we present a case study on how the participatory method MARISCO[1] (Ibisch and Hobson 2014; Schick et al. 2017) can be used to enable knowledge co-production with local communities in a transparent and constructive way. The potentials, as well as limitations of the process to overcome the above-mentioned barriers are discussed, with a special focus on the power dynamics inherent to the process. For this purpose, we analyzed the outcomes of two recent assessments that were conducted for two neighboring integrated conservancies and community forests in northern Namibia. Since its independence, Namibia has placed great emphasis on the rights of indigenous and local communities to manage their natural

[1] From Spanish: *Manejo Adaptativo de Vulnerabilidad y Riesgo en Sitios de Conservación*, which translates as ‘adaptive management of vulnerability and risk at conservation sites.

Table 1 Characteristics of the Khaudum North Complex and the study conservancies

Characteristic	Khaudum North Complex
Adjacent conservation areas	George Mukoya Conservancy and Community Forest (northwest); Muduva Nyangana Conservancy and Community Forest (northeast); Khaudum National Park (south)
Biome classification	Northern Kalahari sandveld
Climate	Average annual rainfall of 500–600 mm
	Average annual temperature of 23.5 °C; min: 6 °C; max: 35 °C
Major wildlife species	Elephant (*Loxodonta africana*), wild dog (*Lycaon pictus*), leopard (*Panthera pardus*), kudu (*Tragelaphus strepsiceros*), plains zebra (*Equus burchelli*), common impala (*Aepyceros melampus*), eland (*Taurotragus oryx*), steenbok (*Raphicerus campestris*)
Approximate population	950 (George Mukoya), 1732 (Munduva Nyangana)
Primary livelihood strategy	Agriculture; livestock farming; tourism; crafts; trophy hunting; own-use hunting; thatching grass, Kalahari melon seed (*Citrullus lanatus*), sourplum (*Ximenia caffra*), and devil's claw (*Harpagophytum zeyheri*) harvesting
Size (km²)	486 (George Mukoya), 615 (Munduva Nyangana)
Source	NACSO (2009a, b)

resources. The internationally acclaimed community-based natural resource management (CBNRM) program of the country has proven to be an effective tool for regional development, economic growth, and poverty alleviation, while promoting the conservation of nature and devolving authority to local communities (Naidoo et al. 2011; NACSO 2016). The community conservancies have been of great importance in this context, because they represent the interface between local communities and government agencies, making them constructive places for the investigation on how to incorporate ILK into biodiversity management, and of the power dynamics between community members internally, as well as with governmental institutions.

Methods

Study Area

The study focused on the George Mukoya (GM) and Muduva Nyangana (MN) conservancies and community forests (in the following called "conservancies") located in northern Kalahari, Namibia, close to the borders of Angola and Botswana (Table 1). Conservancies are community-based protected areas where local inhabitants manage the use of natural resources, especially wildlife. Both conservancies were established in 2005 and are part of the Khaudum North Complex, a protected area network including the Khaudum National Park.

Settlement within this part of Namibia by people from around the Kavango River started in the early 1970s and increased substantially after independence in 1991 as a result of over-exploitation and depletion of natural resources of their former area of residence (Strohbach 2013). This has led to the displacement of the San communities that formerly inhabited the area (Mendelsohn and el Obeid 2003). Most of the San moved southward, however, some members of the community stayed and sought employment as farm workers. Several villages are now located within the conservancies, typically supporting 100–300 inhabitants. Local communities rely heavily on the semi-arid forest as wood pasture for livestock, but also clear and cultivate the land to grow maize and other crops (Falk 2008; Pröpper 2009a). In all cases, wood is extracted for fuel, construction, and non-timber produce harvested for food, medicine, and commercial benefits (Pröpper 2009b). Additionally, tourism and hunting activities within the conservancies make substantial contributions to the economic welfare of the communal residents (Naidoo et al. 2016).

Much of the landscape is shaped by plains formation intercepted by distinctive undulating ridges, so-called Omuramba valleys (incised riverbeds) or fossil longitudinal dunes (Hüttich 2011) (Fig. 1). Environmental conditions across the region are characteristically harsh although the inter-dune depressions offer slightly more favorable habitat for many species because the greater proportion of vegetation cover associated with these features. Despite changes in vegetation cover from high forests dominated by *Pterocarpus-Burkea* toward more open scrub and wooded savannah, the fauna and flora communities remain relatively diverse and abundant compared with more southern regions of the country. A combination of fire, clearing, and grazing drives the degradation processes and dynamics in the forest ecosystem along with the impacts of climate change (Mendelsohn and el Obeid 2003, 2004; Mendelsohn 2005; Stellmes et al. 2013; Röder et al. 2016).

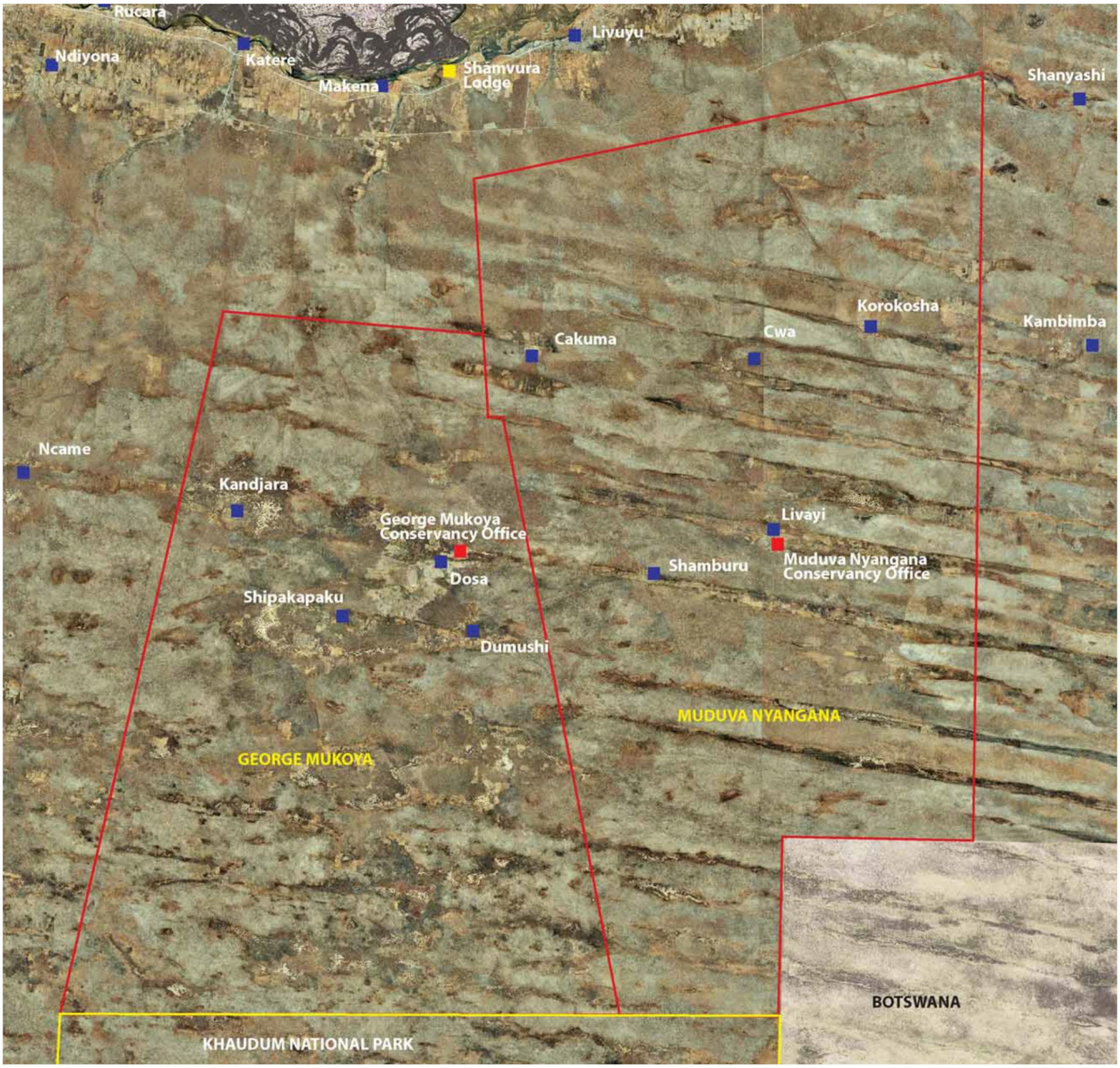

Fig. 1 George Mukoya and Muduva Nyangana Conservancy and Community Forest in northeast Namibia, Source: NACSO 2012, p. 9

MARISCO Method

MARISCO was developed as an adaptive management approach, with the aim to provide a mistake-friendly method that encourages systematic learning from errors in order to build more efficient, resilient, and risk-robust management systems (Ibisch and Hobson 2014). Based on the *Open Standards for the Practice of Conservation* of the *Conservation Measures Partnership* (CMP 2013), MARISCO was designed to deliver robust adaptive management solutions, which are ecosystem-based as called for by the Convention on Biological Diversity (2004) (Salvaterra et al. 2016; Schick et al. 2017). The MARISCO approach encompasses 29 steps divided into four interrelated phases (Fig. 2, for a short description of the steps of the MARISCO method, please consult online resource ESM1). Using colored card coding for different topics, the method enables practitioners to document both knowledge and "non-knowledge" related to biodiversity, threats and drivers of change, as well as the (previous) conservation management for a given site in a systematic fashion. Non-knowledge (in this context) refers to the knowledge that is relevant for decision making, but which, for a variety of reasons, is not considered or (still) unknown (Ibisch and Hobson 2012). The perceptions, assumptions, and knowledge of people who participate in the exercise are captured in the process

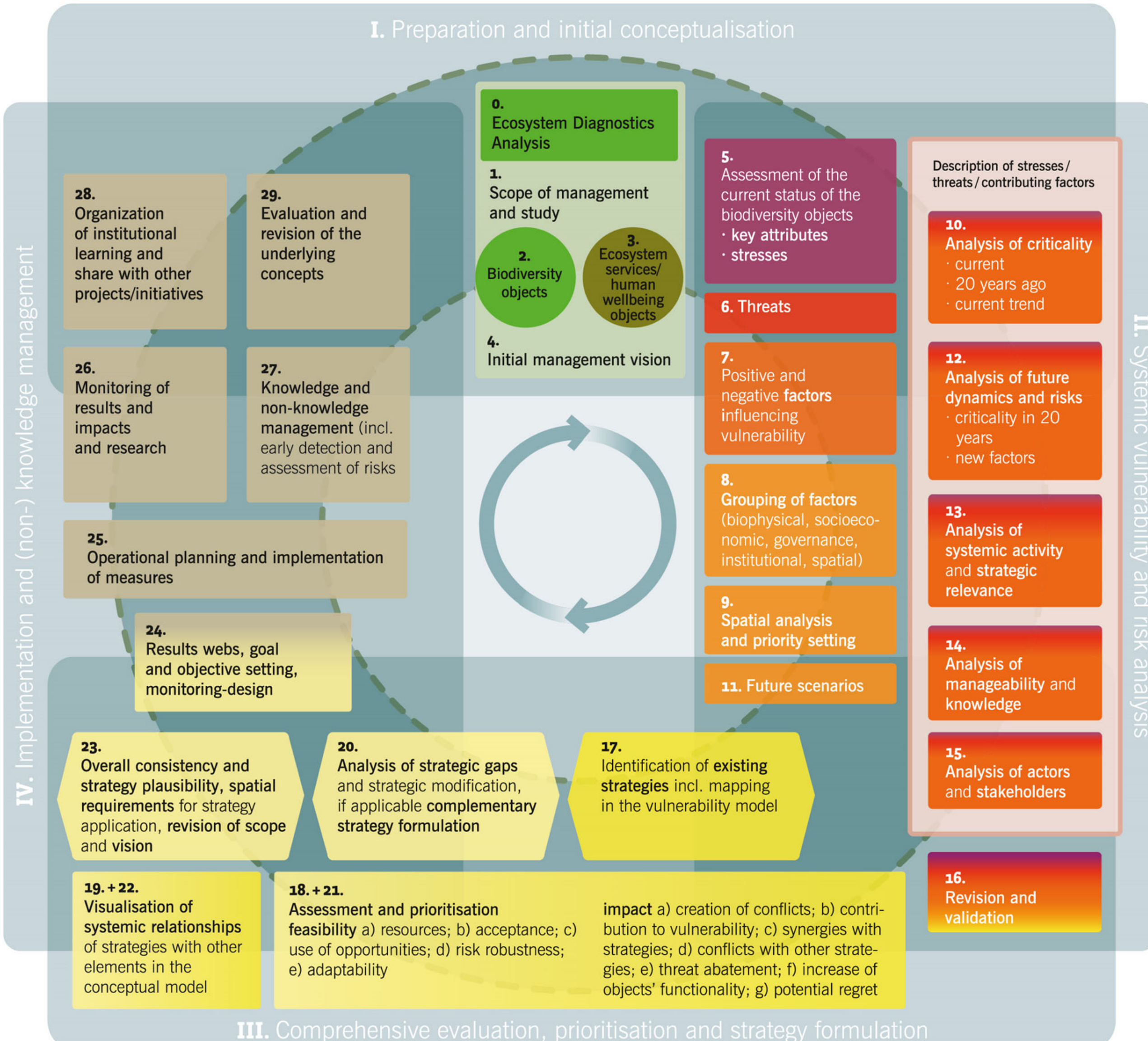

Fig. 2 Overview of the four MARISCO phases: (I) Preparation and initial conceptualization, (II) Systemic vulnerability and risk analysis, (III) Comprehensive evaluation, prioritization, and strategy formulation, and (IV) Implementation and (non-)knowledge management

and represented in the form of a large systemic conceptual model. In previous projects, MARISCO has been used with the participation of local stakeholders, including local and indigenous communities to assess the vulnerability of socioecological systems (Ibisch and Hobson 2015). In the current study, it has been adapted to analyze the socio-environmental situation in two community conservation sites in northern Namibia. For the purpose of this article, we focus on the aspects of the method that facilitate knowledge co-production and address power dynamics during the process, even though MARISCO was mainly applied as a toolbox for supporting a more holistic management planning of the conservancies (Ibisch and Hobson 2015; Ibisch et al. 2015).

Participatory Analysis

Our research team consisted of two senior academic researchers and a PhD candidate, all being trained ecologists and having extensive work experience in the global south, as well as two master students (Global Change Management). The research team was also responsible for the delivery of the workshops. All members of the research team contributed as coaches to the process, although the intensity varied among team members. The senior researchers and the PhD candidate provided most of the workshop facilitation, while the master students preformed mainly tasks related to the work flow and documentation. Participatory workshops were carried out in the context of the *Biodiversity Management and Climate Change* (BMCC) Project of the Ministry of Environment and Tourism (MET), for and in partnership with *Deutsche Gesellschaft für Internationale Zusammenarbeit* (GIZ) GmbH, and were commissioned by the German Federal Ministry for Economic Cooperation and Development (BMZ). The main goal of the workshops was to establish the character and causes of socioenvironmental vulnerability in both conservancies in order to provide a more informed baseline of understanding to help with the development of ecosystem-based adaptation measures to climate change. The workshops were preceded by an ecosystem diagnosis analysis (EDA), the first stage of MARISCO, which is designed as a rapid assessment of conditions and change in a designated ecosystem. In the case of the Namibian study, it involved the use of Google Earth; a desktop study of environmental and biological characteristics of the area based on published reports; the use of local scaled maps to help target landscape and habitat features identified in the wider spatial analysis; an assessment of the specific socioecological status of the communities; and two in-field surveys. Field surveys extended to 2 whole days, and the research team was accompanied by local experts, members of the management committees for both conservancies, and staff of the BMCC project. For a more detailed description of the specific components of an EDA, please consult the MARISCO manual (Ibisch and Hobson 2014).

The assessments formed part of the activities of the BMCC project within the study area and were conducted between March and July 2015 in the form of a series of two 3-day long participatory workshops before the results were finally analyzed. Over 60 local community members and staff from both national and local governments, as well as international and local NGOs participated in both workshops. The community members were selected by staff of the BMCC project in coordination with their counterparts in the conservancies and included members of the management committees, game guards, headwomen and headmen, community members, as well as two farm workers belonging to the San community. The criterion used for selecting participants was to ensure members best represented the full social spectrum of local society, and other parties with either local, regional, or national interests in the landscape.

To help capture a true representation of the situation, the workshops were conducted in *Gciruku*, the local language of the people, and the information transferred to the conceptual models before being translated into English. The conceptual models, as well as all other workshop materials were elaborated in *Gciruku* with English captions for the coaches. The steps taken during the workshops followed the prescribed method, including opportunities given to participants to review and modify responses when needed (see Ibisch and Hobson 2014). The working process included presentations, phases of group work, and plenary discussions, according to the specific consecutive steps of the MARISCO cycle. The participants were divided into two groups and each group was tasked to analyze one conservancy. The community members were assigned to the groups according to their provenance, whereas the other participants were allowed to choose their group, given that representatives of all institutions were present in both groups. To ensure an ongoing information exchange in-between the two groups working in parallel, the participants regularly had opportunities to review and discuss the results of their peers.

At the beginning of the first workshop, the coaches established the rule that any information or opinion provided by a participant would be gathered in the conceptual model. The coaches explained that the participants should not be afraid of coming up with “wrong ideas”, because any knowledge would be regarded as relevant and all elements of the model represented hypotheses that were to be evaluated in the course of the assessment. The participants were allowed to modify the conceptual model throughout the process and add or remove elements, if they had the approval of the group.

The starting point of the assessments of the socio-ecological systems was the identification of the main attributes of human wellbeing by the participants (“state of health, happiness and living a good life with which one is satisfied” – Sarvimäki 2006). The identified elements were categorized into those that could be derived from nature and others that were provided by society. The participants identified the social services that lead to human wellbeing, as well as the social systems that provided these services. Those attributes of human wellbeing that were safeguarded by nature represented the ecosystem services. Using large-scaled satellite images, the participants were asked to identify and record on to the maps the areas that were the source of the ecosystem services, as well as the biodiversity objects that were essential for these services, including specific types of vegetation and species. Finally, the participants were asked to mark the geographic distribution of the identified areas within these maps, resulting in a detailed picture of the ecosystems, as well as significant agricultural areas.

The development of the conceptual model continued with the identification of the key ecological attributes. Using local descriptions of the concept, the participants were requested to list all the elements that the (agro-) ecological systems needed in order to function properly. This step was followed by the identification of the stresses, which were described as the symptoms and manifestations of degradation of the key ecological attributes (“illness of nature”). The participants then identified the threats, human-induced forcing or pressing factors that directly or indirectly affect the natural structure and dynamics of one or a number of components of an ecosystem (“factors that cause and drive illnesses in nature”). By mapping the threats into the schematic model, the stakeholders were in a better position to understand the complex relationships between ecological attributes, stresses, and those threats that combined or exacerbated other threats in the system. The development of the conceptual model was completed with the identification of the contributing factors, which were defined as human actions or activities that directly or indirectly resulted in the emergence of a threat. All of these identified elements were written on single cards and placed into the conceptual model. The participants used black markers to draw arrows between connected cards, in order to highlight the interlinkages between the elements of the conceptual model. During a series of steps, the participants evaluated the stresses, threats, or contributing factors according to their states of criticality, dynamics, and levels of knowledge and manageability. Using four color-coded rating levels, each card was marked up with the perceived rating for each of the above-mentioned descriptors. For a detailed description of the rating categories, please consult the online resources ESM2 and ESM3.

Prior to the second workshop, all the information that was collected during the first workshop was processed and transcribed into a digitized format. The interlinkages between the elements of the conceptual models that were drawn by the participants during the workshop were completed by the coaches using matrices and inserted into the models in the form of arrows. The number of incoming and outgoing arrows of each element was used to calculate the systemic activity of the elements. The “systemic activity” is an indicator of the activity of an element within the complex system, and contributes to the strategic relevance. Final printouts of the conceptual models were produced, as well as lists, ranking the contributing factors, threats, and stresses according to their strategic relevance (see online resources, ESM4 and ESM5 for conceptual models and ESM6 to ESM11 for ranking lists). This numeric value sums up the outcomes of the different ratings undertaken during the first workshop, and calculated values were used to identify the most relevant elements in the conceptual model for strategic development.

At the beginning of the second workshop, the participants were given time to review the conceptual models, rankings lists and maps, to ask questions, and to make modifications. Once all the participants were satisfied with the conceptual models, they were asked to identify the main stakeholders within the system and to map them in the conceptual model. Stakeholders were divided into two groups according to whether their influence was considered mainly positive or negative.

The main purpose of the second workshop was to identify the various strategies that were implemented by the diverse actors involved in the management of the natural resources of the conservancies. Although working in smaller groups the participants were asked to match the stresses and threats identified during the first workshop to the associated areas of activity (e.g., the stress, “Shortage of water” was matched with the area of activity “Water resource use”), and to identify the livelihood strategies they have developed to cope with these problems. Once this task was completed, the next stage of developing complementary strategies for the most pressing problems was undertaken. A rationalization of the strategies was carried out based on the availability of necessary resources, the acceptance by relevant stakeholders, the technical infrastructure to make feasible implementation, the ability of a strategy to resolve problems, and the potential generation of new problems. Details on the rating tables are included in the online resource ESM12.

Finally, the representatives of the *Ministry for Environment and Tourism* (MET), the *Namibian Nature Foundation* (NNF), the *Ministry of Agriculture, Water and Forestry* (MAWF), the *Directorate of Forestry* (DoF), and the *Deutsche Gesellschaft für Internationale Zusammenarbeit* (GIZ) were given the opportunity to present their roles and ongoing activities within the conservancies. The strategies of these external organizations were collected and critically discussed in small groups. Participants were required to identify failures and problems concerning the work and cooperation with these institutions, and to come up with possible solutions. In order to help avoid embarrassment or reluctance among community participants to come forward, those stakeholders representing the various institutes were invited to step outside for the necessary period of time to complete this stage. The results were presented to the organizations in a plenary session. During the last step of the assessments, the small working groups of both teams were asked to select the five most important strategies implemented at local and conservancy level and to incorporate them into their conceptual model. This led to the development of basic result webs that were used to demonstrate the numerous interlinkages of the strategies and the elements of the conceptual models. After the workshop, the result webs were completed to test the overall consistency of the strategic portfolios.

A follow-up workshop was conducted in April 2016, after the results of the workshops had been processed and returned to the conservancies. The coaches discussed the overall consistency of the strategic portfolio with the participants, as well as the implementation of the developed strategies and the monitoring design.

Statistical Analysis

All statistical analyses have been performed using the R 3.3.2 base package (R Core Team 2016). The elements of the conceptual models were transcribed into spreadsheets and rank values were produced for all evaluated elements, namely the stresses, threats, and contributing factors. A Kruskal–Wallis rank-sum test was performed to test for any differences between the data sets of the two stakeholder groups. In order to test for differences within the data sets, Mann–Whitney *U*-tests were performed, including Bonferroni corrections of the resulting *p*-values.

Results

Conceptual Models

In the final analysis, the participants of GM identified 160 elements (everything from nature value attributes, to threats, stresses, and contributing factors), for the ecosystems in their conservancy, and the team from MN documented 168 elements, all within nine categories. The descriptions of the biodiversity objects were very detailed including a multitude of fruit, plant, tree, and animal species that were associated with one or more of the identified ecosystems. The participants identified six ecosystems for both conservancies, including dense forests, open woodlands, bushlands, grasslands, water pans, crop fields, and grazing grounds. Within GM, the participants identified saltpans as an additional ecosystem. The team assessing GM identified 11 stresses, 13 threats, and 74 contributing factors belonging to seven groups and three subgroups, whereas the MN team identified 16 stresses, 13 threats, and 76 contributing factors divided into eight groups and three subgroups.

In total, between the two groups of participants, 930 evaluations were made based on the criticality of all the stresses and threats, as well as the majority of the contributing factors. Because of time constraints during the second workshop, the evaluation for contributing factors remained incomplete, and further work would be needed to finish the task. Using the evaluations, priority lists were generated for the stresses, threats, and contributing factors, ranking each element according to its strategic relevance. Stresses and threats were divided into groups according to the unified IUCN-CMP classifications (Salafsky et al. 2008). The majority of the identified stresses existed at ecosystem level, and related to perceived ecosystem degradation (1.2), as well as indirect ecosystem effects (1.3), whereas species-specific stresses played only a minor role. Of all the stress conditions documented by both participant groups, those relating to changes in abiotic conditions, including heat stress, changes in seasonality, and biotic changes such as drying out of trees and grass, the decrease of agricultural productivity and soil fertility and the loss of tree cover and habitat were ranked highest in terms of criticality.

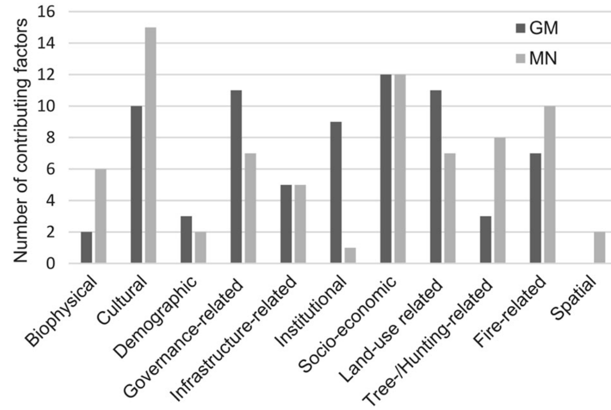

Fig. 3 Overview of the contributing factors of the George Mukoya (GM) and Muduva Nyangana (MN) conservancies classified into groups and subgroups according to their thematic domains

The most important threats can be divided into three groups. The first group encompasses all threats relating to the changes in local climate, including drought, increased variability, lack of rain, and the increase of temperature (categories 11.2 Drought and 11.3 Temperature extremes of the unified IUCN-CMP classification). The second group includes fire-related threats (7.1 Fire and fire suppression), both natural and manmade fires, whereas the third group addresses the unsustainable use of trees and the consequences of deforestation (5.3 Logging and wood harvesting).

The contributing factors were classified into groups and subgroups according to their thematic domains (Fig. 3). Amidst the contributing factors of GM, the most critical drivers of change were found within the demographic, socioeconomic, and infrastructure-related groups. Within MN, biophysical drivers also played an important role.

One of the objectives of the study was to identify the common values and attitudes of communities from two conservancies in a shared landscape, but also to recognize where there were perceived differences. A statistical analysis of the results for the evaluation of stress conditions did not reveal any significant differences in perceptions between the two conservancy teams (Mann–Whitney *U*-test, $N_{GM} = 11$, $N_{MN} = 16$, $p > 0.05$), and similarly for threats (Mann–Whitney *U*-test, $N_{GM} = 13$, $N_{MN} = 13$, $p > 0.05$; Fig. 4). In contrast, an analysis of contributing factors revealed significant differences in response values between the two groups (Mann–Whitney *U*-test, $N_{GM} = 58$, $N_{MN} = 44$, $p < 0.001$). However, further comparison of factor groups confirmed only one significant difference between the fire-related factors (Mann–Whitney U-test, $N_{GM} = 7$, $N_{MN} = 8$, $p < 0.05$; Fig. 5).

Many of the threats and contributing factors were common to both teams but noticeable differences in the emphasis placed on importance of each factor were revealed. For instance, the group working on the GM conservancy expected the criticality of the drivers of ecosystem degradation to decrease over time, whereas the members of the MN group expected them to increase. This led to opposite assumptions for the future state of the conservation objects, with an expected improvement in GM and further degradation in MN. In GM, 69.0% of factors were considered more critical in the past, whereas MN group felt 35.6% of the factors were historically more critical. Conversely, 17.2% of the factors recorded among the GM team were thought to have been less critical in the past unlike the result for the MN participants where 64.4% of factors were deemed less critical. The impacts of climate change featured more prominently in the situation analysis carried out by the GM group although the contributing factors related to climate change were rated less critical by GM members than by those representing MN.

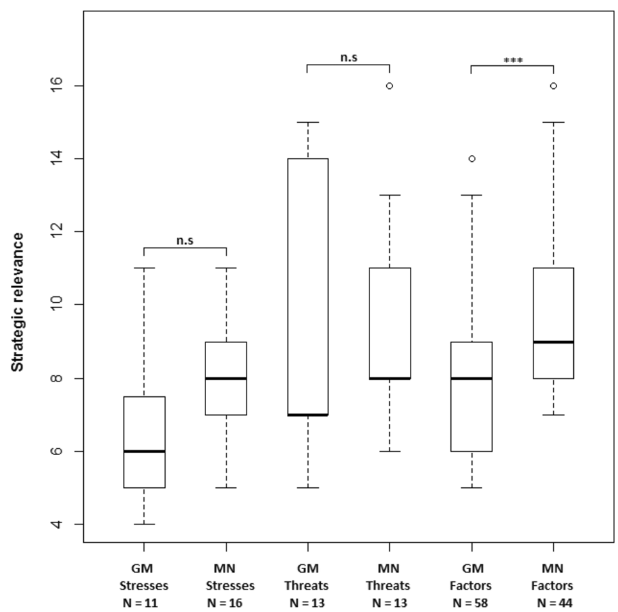

Fig. 4 Comparison of the strategic relevance of stresses, threats, and contributing factors of the George Mukoya (GM) and Muduva Nyangana (MN) conservancies. Data are shown as median ± ¼ quartile (***$p < 0.001$; n.s not significant)

Maps

After a short introduction, the participants were able to navigate the satellite maps with ease. The use of colored markers and stickers proved to be very practical. The maps developed by the participants provided a detailed spatial record of ecosystems of the study area and the services they provided, as well as an accurate location of significant agricultural areas and important features of biodiversity, including groups and species. It became evident that the local communities went to considerable effort to minimize disturbance in the wildlife zones. However, the future prognosis for these wildlife sanctuaries is in doubt, as most of the areas within the communal lands that were marked to be of high fertility and supporting dense vegetation cover were already being used for agriculture and livestock farming. Through the process of threat mapping, a spatial representation of the distribution and intensity of threats to biodiversity across the study areas was developed. This process helped to increase the understanding of the spatial distribution of the various threats within the conservancies and to prioritize areas of intervention. Finally, the maps were used to discuss the spatial aspects of the strategic portfolio, as well as the potential constrains to their successful implementation that arise through the geography of the conservancies.

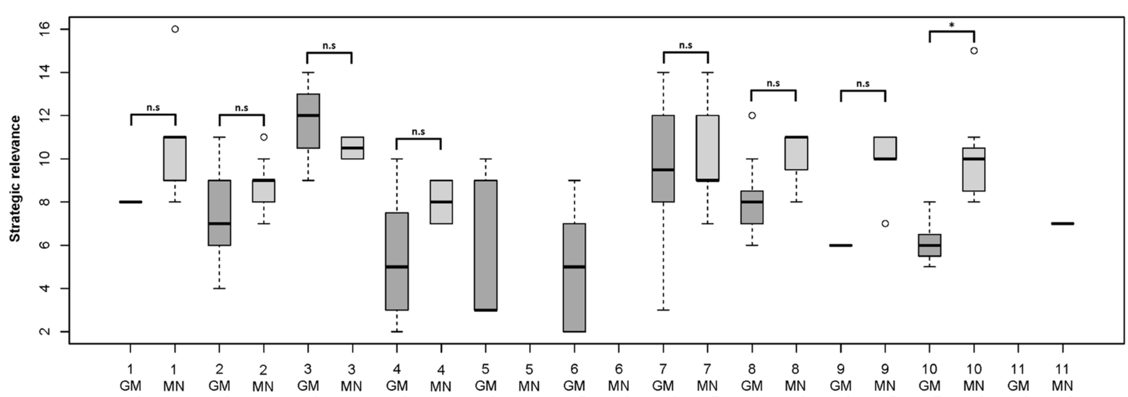

Fig. 5 Strategic relevance of the contributing factors of the George Mukoya (GM) and Muduva Nyangana (MN) conservancies: (1) Biophysical; (2) Cultural; (3) Demographic; (4) Governance-related; (5) Infrastructure-related; (6) Institutional; (7) Socioeconomic; (8) Land use related; (9) Tree-related/Hunting-related; (10) Fire related, and (11) Spatial factors. Data are shown as median ± ¼ quartile (*$p < 0.05$; n.s not significant)

Stakeholders

At the beginning of the second workshop, the participants identified the relevant stakeholders for each of the thematic groups of contributing factors and rated their influence as being mainly positive or negative (see online resources ESM13 and ESM14). Several of the identified actors were attributed to have both positive and negative influences, highlighting the complexity and ambiguity of the described socioecological systems. The more obvious negative impacts causing ecosystem degradation were related to the direct use of natural resources by local communities. Whereas on matters linked to decisions-making processes that affect the lives of local inhabitants, actors including local authorities, community members, ministries, and donor organizations were rated as having a positive influence.

The stakeholder analysis undertaken by the participants is far from being complete, but helped to sensitize the participants to the different interest groups present in the study area. This proved to be very useful for strategic development. Further opportunities for knowledge co-production could be created at this stage by including more experts to analyze the stakeholders involved in the socioecological system of the study area.

Strategies

During the second workshop, participants identified existing strategies that were being implemented in the study area, as well as novel strategies to resolve outstanding problems (Table 2). In order to demonstrate the interlinkages between the different tiers of society, as well as the top–down and bottom–up processes of order and information flow, the strategies were organized and structured by the coaches in the form of a pyramid (see online resources ESM15 and ESM16). Even though the participants did not develop this form of presentation by themselves, they quickly embraced the concept. All strategies were divided into four categories according to the size of the social system responsible for implementing a specific strategy. The ecosystems and biodiversity objects were positioned at the bottom of the pyramid, because they form the base for all resource-related activities. Local livelihood strategies implemented by the inhabitants of the conservancies were considered to be at the scale of lowest order, followed by the strategies at conservancy level, and finally, at the top of the pyramid, those coordinated by external authorities like NGOs and the government. Nine general areas of activity were identified for the local livelihood strategies, which were the following: hunting tourism; water resource use; crop production; animal production; production of vegetables in gardens; use of forest resources for fire wood (cooking); use of natural material for crafts to sell; use of natural material for construction and tools; and natural resources sold for income (e.g., Devil's claw, *Harpagophytum procumbens*). Overall, the participants of GM gathered 101 strategies for their conservancy, including 50 existing strategies and 51 complementary strategies, whereas the participants of MN collected 37 existing strategies and 63 complementary strategies, summing a total of 100 strategies. The number of strategies was not distributed evenly between the different social levels of society. Most of the strategies designed to address immediate problems were directed at community and conservancy levels (GM: 43; MN: 38). Those strategies targeted at community level were to safeguard livelihoods, and those written for conservancy level action focused on social and political problems. Existing strategies implemented by government institutions, donors, and NGOs were targeted at problems relating to society and management, and yet the response of the workshop participants indicated that their actions were not really perceived by the communities and that knowledge about responsibilities and actions of the different actors was generally very low. Equally, the large number of complementary strategies proposed to deal with issues surfacing at institutional and governmental levels (GM: 17; MN: 24) illustrated the demand for assistance and support for community members to provide and secure basic needs for the local inhabitants. Most of the new proposals were designed to provide for more sustainable adaptations and solutions for the use of natural resources in the face of changing socioeconomic, demographic, and sociocultural conditions.

The participants chose the 20 most important strategies for each of their conservancies and inserted them into the conceptual models next to the threats and contributing factors effecting the ecosystems. This step intended to reveal to the participants the scale of interrelationships between the various elements of the socioecological systems depicted in the conceptual models, as well as some of the negative feedback loops likely to reduce the effectiveness of some of the strategies. The exercise also exposed the encumbrance and inefficiencies of a number of institutional or governance-related actors in addressing sociocultural issues, and the limitations of the participants to exercise positive change in living conditions. This last point was expressed in terms of training needs and education. Fourteen out of 40 strategies chosen by the participants were related to the need for improved knowledge and education in order to be able to take well-informed decisions and to manage their natural resources sustainably. There existed some differences between the two groups in the selection of the most important strategies, yet both groups selected strategies that addressed the access to water, fire management, and transportation.

Table 2 Distribution of existing and complementary strategies according to the scale of the social system implementing the strategy

	George Mukoya			Muduva Nyangana		
Level of implementation	Strategies related to	Existing	Complementary	Strategies related to	Existing	Complementary
Government	Safety	0	2	Quality of life	0	2
	Education	2	1	Implementation	0	3
	Human wildlife conflict	1	1	Wildlife	0	2
	Other	0	2	Infrastructure	0	7
				Patrolling	0	2
				Training	0	3
				Sustainable resource use	0	3
	Subtotal	1	10	Subtotal	0	22
Institutions, donors, NGOs	Income generation	0	2	Income generation	0	1
	Food provision	0	2	Cooperation	1	0
	External influence on conservancies	0	4	Infrastructure	0	1
	Subtotal	2	7	Subtotal	1	2
Conservancy	Fire	4	2	Fire	1	1
	Infrastructure	0	2	Infrastructure	1	1
	Resource management	3	2	Resource management	4	3
	Training	4	11	Training	3	8
	Conservancy structure	4	0	Income generation	1	4
	Water	4	4	Spatial planning	1	0
				Wildlife	1	0
				Poaching	3	0
				Patrolling	2	0
				Penalties	1	2
				Cooperation	0	1
	Subtotal	19	19	Subtotal	18	20
Community	Trees	8	3	Trees	2	2
	Fire	3	2	Fire	2	4
	Wildlife	6	2	Wildlife	2	1
	Agriculture and livestock	3	4	Agriculture and livestock	6	8
	Income generation	6	0	Income generation	4	2
	Sustainable usage of resources	2	4	Change of livelihood	1	2
				Infrastructure	0	1
	Subtotal	28	15	Subtotal	18	19
Total		50	51		37	63
Overall		101			100	

Discussion

Potentials and Shortcomings of the Participatory Analysis

With its holistic approach, the MARISCO method encourages transparent and adaptive approaches to represent complex socioecological systems. It also allows for the integration of local knowledge and more conventional, science-based approaches to knowledge gathering. In the case of the two Namibian conservancies, overall coherence of iterative analyses done by the two distinct groups indicates that the outcomes of the assessments were not just erratic assumptions of the participants. Rather, the results seem to realistically reflect the local situations.

Despite the general consensus between the two conservancy teams, there were a number of differences, specifically concerning between the evaluation of fire-related risks. This may have something to do with the distribution and frequencies of fires, and also with the prevailing direction of burn from east to west. The local inhabitants postulated that many of the fires were started over the border to the west in Botswana and that fire traveled eastward through MN before reaching GM. The presence of a large firebreak stretching along the border between the two conservancies would have helped in the prevention of uncontrolled burns in GM. During the brief survey in the field carried out by the research team, extensive damage by fire was observed throughout both conservancies. There were no areas untouched by repeated fire disturbance and in most parts of the landscape forest cover had been reduced to open wood pasture and tall scrub. It is unlikely that the scale of burn was solely attributed to uncontrolled burns from Botswana, and that another contributing factor would be deliberate burning by locals to create grazing land for livestock. It is quite likely that the local farmers played down the extent of deliberate burning by the inhabitants of the region.

The general findings of the assessments support evidence generated in earlier scientific studies carried out in the area. The participants ranked heat and hydric stress, as well as a reduction in the productivity of the ecosystems as the most critical stresses within the conservation sites, and this is born out by independent sources (Hulme et al. 2001; Government of Namibia 2002; Hudson and Jones 2002; Woodward and Lomas 2004; Midgley et al. 2005; de Wit and Stankiewicz 2006; Dirkx et al. 2008; Turpie et al. 2010; Field et al. 2014). Other concerns raised at the workshop to do with local weather events (categories 11.2 Drought and 11.3 Temperature extremes of the unified IUCN-CMP classification), forest fires (7.1 Fire and fire suppression), and the unsustainable use of trees and deforestation (5.3 Logging and wood harvesting), have also been published elsewhere (Ashley 2000; Scholes and Biggs 2004; Vogel 2006; Strohbach and Petersen 2007; Pröpper 2009b). Among the contributing factors, climate change, overpopulation, hunger, poverty, and demand for land were considered the most important drivers of change. In combination, these factors are describing a negative feedback loop that has also been identified by scientific studies (Reid et al. 2007; Biggs et al. 2008; Sheeran 2008; Lobell et al. 2008).

Some evaluations relating to natural conditions such as species and extent of forest cover failed to recognize the ongoing decline in biodiversity, and the changes in the composition of plant and animal communities. There could be two very different reasons for these “blindspots” one of which is the creeping rate of change relative to the average lifespan of a local inhabitant, sometimes referred to as the “shifting baseline syndrome” – indiscernible changes in the environment (Pauly 1995; Vera 2009). The other reason could relate more to life choices and priorities dictated by prevailing conditions. All of the participants were living in hardship frequently driven by shortages of food, water, and immediate access to basic health care. Daily stresses and uncertainty are likely to focus attention on immediate needs for survival and priorities linked to individual wellbeing. Previous studies in the Kavango Region have already shown that ecological knowledge of the farmers is clustered around utilitarian criteria (Pröpper 2009a).

Given the short duration of the workshops, it is unlikely that the diverse knowledge systems have been captured in all their depth. The resulting conceptual models depicting the complex situations are far from being complete, although they do present a point of departure for the joint development of strategies. As it is envisioned in the adaptive MARISCO approach, the conceptual models are not static objects, but dynamic entities that would follow the constantly changing and evolving socioecological systems they aim to depict. As a study by Schnegg et al. (2014) demonstrated the knowledge of the local population in the region is processual and value based and deeply embedded in rapidly emerging modern market structures, as well as traditional cosmologies. This highlights the potential of the MARISCO method to document the complexities of local knowledge systems that are under constant change.

Biodiversity knowledge of indigenous people and local communities are often partly shaped by spiritual belief and nonmaterial relationships between humans and their environment. In the case of the representatives from both conservancies, the importance of god in shaping and steering the lives and conditions of the inhabitants was a repeated theme in discussions. Even though all participants considered themselves Christian, traditional concepts of religion were still commonly used to interpret current events. For instance, freak weather patterns were often interpreted as divine retribution for misdemeanors committed by individuals or whole communities. Such coexistence of religious concepts has been documented by other studies within the Kavango region (Pröpper 2009b, Schnegg et al. 2014). It is likely that the representatives of the San community would have had their own concepts, but given to their quiet and restricted manner their voices remained unheard in this matter.

In feedback statements, participants claim that the MARISCO method has deepened their understanding of people’s interactions with the environment and has provided them with new insights based on existing, but unconnected and “invisible” collective knowledge. Similar positive effects on systemic thinking and the identification of interlinkages in complex socioecological systems have been reported for community-based scenario planning (Waylen et al. 2015).

The outcomes of the MARISCO assessments can provide further opportunities for knowledge co-production and the results, especially the conceptual models, are powerful boundary objects. Boundary objects are defined as co-produced outputs that are adaptable to different viewpoints, yet robust enough to maintain identity across them (Star and Griesemer 1989). They can be used to coordinate the actions of diverse stakeholders despite their different interests and have the potential to increase the credibility and legitimacy of information production processes (Cash et al. 2003). The workshops also presented a platform for governmental institutions and NGOs to present their work and to receive feedback from the local communities.

Participants from local communities readily embraced opportunities to share knowledge with other stakeholders in the understanding it would greatly improve collective knowledge about the system and some of the current socioenvironmental problems experienced by the local communities. The identified feedback loops and knowledge gaps can serve as new opportunities for collaborative activities and the development of synergies between ILK and science.

Different knowledge systems are often complementary in terms of the scale in which they are analyzed, and a combination of approaches can lead to better understanding of cross-scale interactions (Laidler 2006; Gagnon and Berteaux 2009). Scale is rarely considered during the planning stages and final management of natural resources for reason targets are commonly defined at national or even international level without due consideration of the needs and concerns expressed at the grassroots of a community. Through participatory analysis, applying standardized methods, local communities can have their concerns heard and addressed, and are empowered to communicate their interests and views in a common language up through the ranks of social institutions and governments (Reid et al. 2006). A more integrated and participatory approach to situation analysis and planning should generate realistic expectations for any proposed management strategy, and also encourage ownership of the project by all stakeholders (Webler et al. 2001; Bouwen and Taillieu 2004; Schreiber et al. 2004; Haywood et al. 2016).

Furthermore, the parallel assessments largely facilitated the horizontal exchange of knowledge between both the participants as individuals and the two neighboring conservancies. Participants greatly valued opportunities to report on their workshop achievements and to review and discuss the results of the other group, while working through the methodological steps. It has been demonstrated by a study in northern South America that indigenous community members were significantly more receptive to solutions emerging from, and communicated by, other indigenous peoples, and that this approach was a significant motivating force for encouraging change in their own community (Tschirhart et al. 2016).

Mutual trust and respect are preconditions for knowledge co-production, but are slow to build up (Pretty and Ward 2001). Based on the co-management literature, the development of working relationships among holders of different kinds of knowledge takes time, typically about 10 years (Berkes 2002). It signifies a considerable obstacle to knowledge co-production through this approach, because knowledge holders are unlikely to share their knowledge during short-termed assessments. However, the long lasting relationship of the BMCC project staff with the community members is likely to have compensated at least partially for that.

Implications of Power Inequalities for the Participatory Process

The structure of any participatory process that encourages input from a broad spectrum of interested members of society is founded on democratic principles, namely, to allow people from all backgrounds who have an invested interest in the living environment around them to influence decision making during planning and management of the living landscape. MARISCO is designed to document a diversity of information and knowledge in an orderly and democratic way that is both clear and transparent to all irrespective of their personal educational circumstances, and to produce consensus among all by the end of the process.

Nonetheless, participatory processes do not take place in a political vacuum and power inequalities are likely to influence their outcome. Power inequalities can exist between the communities and the external participants, as well as within the communities, who have been shown in previous studies to be internally differentiated according to gender, class, race, wealth, education, or age among others, producing local power relations that confer differentiated access to and control over natural resources (Nightingale 2003). These inequalities will have significant influence on how the participants experience the process and a sound understanding of the intra-community power relations and patterns of inequality is crucial for the interpretation of the outcomes (Funder et al. 2013). Yet, it remains open for debate whether snapshot assessments and studies are capable of capturing power dynamics embedded in and exercised through everyday social relations that are mediated by culture and history (Tschakert et al. 2013).

Although MARISCO workshops are designed to provide neutral spaces, where all participants could express themselves and be heard, it is possible that more vocal and politically articulated participants may have dominated the debate to a certain extent and obscured the voices of others. Men and women worked in mixed groups and interacted. There were active and outspoken representatives among both sexes. In the course of the assessment, the dynamic and iterative methodology allowed for working in breakout groups, which proved to be better suited to capture diverse knowledge and points of view, even for participants who dislike speaking out in front of the plenary. The two members of the San community remained quiet observers throughout the better part of the workshops and preferred to communicate their thoughts through the voices of others, instead of addressing the entire group directly. In our view, it seems unlikely that the knowledge of the San community were accurately represented. The invitation to all participants during the brainstorming exercises to record their ideas on cards proved effective in widening engagement, although low literacy was an ongoing challenge.

Literacy levels of the participants were not evaluated during the assessment; hence no quantitative description can be made. The research team had the impression that the majority of participants were able to read, and a slightly smaller percentage was able to write. In the course of the workshops, the literacy levels did not seem to have a large impact on the engagement of participants in the study. Almost all participants took an active part during the discussions and asked the coaches, translators, or fellow participants to write down their ideas if they were unable to do so themselves. The full benefits and outcomes of the workshops are unlikely to be appreciated by non-literate members as findings were presented to the communities in the form of written reports. During the third workshop series, the coaches provided pictures on each of the cards in order to ensure that all participants could follow the discussions. The use of pictograms or photos is feasible and could greatly enhance the accessibility of the conceptual models for illiterate participants.

Overall, the mapping exercises proved to be very useful tools for the assessment of the multiple interactions that rural communities have with their environment. This has also been demonstrated by other mapping exercises in northern Namibia. Rieprich and Schnegg (2015), for example, combined ethnography with participatory mapping during the assessment of ecosystem services within the Mahahe community near Rundu. Their findings revealed that the participants often experienced material and nonmaterial services and social interactions simultaneously in a given landscape and that the divide between the lines of nature versus culture, material versus nonmaterial, or work versus leisure fell short of capturing the perceptions of the community members. During their assessment of poaching risks in two community conservancies in Caprivi, Kahler et al. (2013) found that the locations of documented poaching events were spatially correlated with areas where stakeholders perceived wildlife as a threat to their livelihoods. However, the recorded poaching events and stakeholder perceptions of where poaching occurred were not spatially correlated. Although the perceptions given by the stakeholder provide valuable information for the management, they also indicate that local perceptions have to be evaluated carefully (Treves et al. 2006).

Natural resource utilization is a social process in which different interest groups, with diverse and often conflicting intentions, confront each other at local, regional, national, and global levels (Schmink and Wood 1992). The holistic character of the MARISCO approach helped to identify several issues related to power inequalities and access to resources. One of the most complex conflicts within the conservancies existed around hunting tourism. This activity generated a substantial portion of the revenues of the conservancies, yet the costs and benefits were distributed unevenly among the involved parties, as well as the communities internally. The hunting operators and conservancies had strong interest in pristine landscapes and large animal populations, because they attract tourists and generate income. These stand in contrast to the interests of the community members living in villages closest to the wildlife zone, because they had to face the negative impacts of human wildlife conflicts. A study by Khumalo and Yung (2015) in the Kwandu conservancy revealed that especially the most vulnerable community members had to burden the costs of human wildlife conflict, which exceeded direct material losses and included hidden impacts such as persistent worries about food insecurity, fears for physical safety, and lost investments.

The inhabitants of the villages closest to the wildlife zones also complained that these restricted areas limited opportunities for expanding cropping and pasture lands, and the benefits derived from hunting operations were deemed to be insufficient to compensate for the lost opportunities. This led to the invasion of the wildlife zones in several occasions and to conflicts among the involved parties. Such conflicts were expected to increase in the future, because population growth will put more pressure on natural resources already limited in supply. At the same time, the legal status of the conservancies help the communities to secure their access to land against other communities from outside and to protect their territory from land allocations of the Ministry of Agriculture.

Participatory processes can be used by communities to secure their access and control over natural resources, as has been demonstrated by a study in Tanzania, where communities transformed a participatory natural resource monitoring scheme to assert their claims to territory and resources vis-a-vis the state, other communities, and other community members (Funder et al. 2013). Further research in the project site in Tanzania revealed that the information produced and communicated by the community members contradicted trends in wildlife densities and human disturbance observed in the forest and under-represented actual financial flows, indicating that the communities involved in this monitoring scheme were subject to power struggles and modified the information according to their interests (Nielsen and Lund 2012). This could also be the case in this assessment when the participants were asked to evaluate the extent of deliberate burning by the inhabitants of the region.

The examples given above highlight the complexity inherent in rural participatory processes. Rather than thinking solely in terms of short-term financial benefits, indigenous and local communities may also have more long-term and indirect concerns such as ensuring food security and enhancing territorial control over resources (Wollenberg et al. 2001; Langton et al. 2005). Furthermore, they demonstrated that communities are active political agents, capable to use and shape participatory processes to ensure their interests are met.

Participatory processes can provide a stage for disadvantaged community members to voice their concerns, but it takes courage to confront authorities and influential community members in plenary sessions and often participants demonstrate restraint (Tschakert et al. 2016). Working in small breakout groups reduced the tensions and encouraged wider participation among participants. This setup proved to be very useful during the rationalization of the strategies. Each breakout group consisted of five to six participants and was tasked to select the five most important strategies. If the group could not agree on a set of strategies each member was allowed to choose one strategy, which increased the probability that the interests of all participants were considered.

The evaluation of the strategies implemented by external institutions enabled the communities to confront the authorities. Unconstrained dialog and discussion among community members was encouraged by temporarily separating institutional reps from the rest of the group members. Afterward, the results were presented in a plenary session. The communities first identified all the strategies that were implemented in the conservancies by the different institutions, which served as a good indicator for the visibility of the activities of the each institution. The use of the same set of criteria that was used for the evaluation of the strategies implemented at community and conservancy level allowed for constructive criticism and also reduced the pressure on the participants to give answers intended to please the donors and institutions.

The various setups of the working process provided also various opportunities for all actors to present their knowledge and to learn from others, including the research team. Yet there is a fine line between two-way learning and manipulation and other studies have found that the judgements of participants can be subject to persuasion (Satterfield et al. 2009). The research team used the introductory presentations to introduce certain topics, for example, climate change and its possible local impacts, to the participants. This might have had an effect on the direction and outcomes of the assessments, although, given the positive feedback of the participants, it seems rather unlikely that the coaches might have exerted a dominant influence on the process. Another common critique of participatory processes involving ILK holders is that external experts would prioritize local knowledge that conforms to their scientifically driven environmental goals (Blaikie et al. 1997; Mosse 2001). As has been mentioned earlier, the coaches inserted every information or opinion that had been given by a participant into the conceptual model, hence the risk of a biased selection was considered negligible.

The resulting reports represent synthesized compilations of the local knowledge, as well as the necessities of the communities and the coaches encouraged the conservancy members to use the reports for negotiations with governmental institutions and donors. Still, the uptake and implementation of the outcomes will most often depend on external factors. At the end of the second workshop, one governmental official asked the participants to stay committed to the process and the identified strategies, but it remained open if the external institutions would do the same. Participatory processes for decision making in natural resources management will have to undergo a series of radical reforms in order to be able to overcome such power asymmetries (Mohan and Hickey 2005; Blaikie 2006), or they will risk to frustrate the participants and ultimately the entire process.

Overarching goal of the exercise was to assess the socioenvironmental vulnerability of both conservancies and to develop ecosystem-based adaptation measures to climate change. During this process, conceptual models were developed that could also be used for management purposes. However, in order to be able to use the conceptual models for this purpose, the communities and government agencies would need further training and assistance. Given the short-termed nature of the project and the limited resources available for such activities, neither was possible. This is clearly a lost opportunity to make valuable contributions to the management of the local natural resources and a limitation of the MARISCO method in general, because its successful implementation requires continuous support (at least in the beginning).

Despite this limitation, the overall feedback of the participants on the process was very positive. At the end of each workshop, the participants were asked to use colored stickers to rate the exercise according to set of criteria, which were used to evaluate the processes. The participants had also the opportunity to leave comments. In order to provide an open space for critique, voting boxes were installed, where the participants could give their answers in private. The occurrence of negative ratings and comments (though few in number), allows for the assumption that the participants felt free to give their honest opinion. Most of negative comments were related to workshop logistics, for example, the transport of the participants from the conservancies, however, another reoccurring complaint was that the participants did not receive a direct payment for their participation.

Conclusion

Our research has demonstrated that working with local communities in an open and transparent participatory manner can make substantial contributions to the wider knowledge base about complex socioecological systems. For many parts of the world, in particular, the tropical regions, there is but a limited scientific understanding of the relationships between nature and culture. This may contrast with the rich tapestry of knowledge housed in the resident communities of the landscape. Sharing of such knowledge offers opportunities to develop novel conceptual thinking about human–nature relationships and to forge innovative solutions for both local and global issues. Throughout the process, MARISCO proved to be flexible enough to be adapted to the specific needs of the participants, including group sizes, composition of gender, age, educational and ethnic background, language requirements, and fine-tuning in timing and location of the work sessions, as well as the implementation of different techniques for the collection and systematization of ILK (Ibisch and Hobson 2015). Nonetheless, this study also highlighted some of the limitations of the method, which might also be relevant for other participatory processes. Power inequalities remained a challenge and special attention has to be paid to the representation and participation of (potentially) disadvantaged groups, especially in processes involving indigenous and local communities. Independent from the purpose of the participatory process, we would like to encourage practitioners and scientists to approach and engage the communities as capable political agents in their own right.

Acknowledgements The research of this study was carried out in the context of a consultancy for the BMCC project. We would like to thank all the participants of the assessments, especially the community members of the George Mukoya and Muduva Nyangana conservancies. We are grateful to Dr. Nadine Faschina, Gerrit Bartels and Dr. Konrad Uebelhör, as well as Carolin Tischtau for helpful comments on the draft and the whole staff of the BMCC project supporting the working process. We would also like to thank the anonymous reviewers for constructive feedback on earlier drafts of this paper. PLI co-conceived and supervised in the framework of the research professorships "Biodiversity and natural resource management under global change" (2009–2015) and "Ecosystem-based sustainable development" (2015 onward) that were awarded by Eberswalde University for Sustainable Development. The workshops were conducted by PLI and CS (workshops 1–3), AS (1), PH and AK (2). AS, CS, and AK processed the data. AS wrote a first draft of the text and moderated its critical revision. All authors contributed to the interpretation of the data and critical revision of further versions.

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

References

ACIA (2005) Arctic climate impact assessment. Cambridge University Press, New York, NY

Agrawal A (1995) Dismantling the divide between indigenous and scientific knowledge. Dev Change 26:413–439. https://doi.org/10.1111/j.1467-7660.1995.tb00560.x

Armitage D, Berkes F, Dale A et al. (2011) Co-management and the co-production of knowledge: learning to adapt in Canada's Arctic. Glob Environ Chang 21:995–1004. https://doi.org/10.1016/j.gloenvcha.2011.04.006

Ashley C (2000) Incentives affecting biodiversity conservation and sustainable use: the case of land use options in Namibia. Directorate of Environmental Affairs - Ministry of Environment and Tourism, Windhoek, Namibia

Aswani S, Lauer M (2006) Benthic mapping using local aerial photo interpretation and resident taxa inventories for designing marine protected areas. Environ Conserv 33:263. https://doi.org/10.1017/S0376892906003183

Berkes F (1999) Sacred ecology: traditional ecological knowledge and resource management. Taylor & Francis, Washington, D.C.

Berkes F (2009) Indigenous ways of knowing and the study of environmental change. J R Soc New Zeal 39:151–156. https://doi.org/10.1080/03014220909510568

Berkes F (2002) Cross-scale institutional linkages: perspectives from the bottom up. In: Ostrom E, Dietz T, Dolsak N, et al. (eds) The drama of the commons. National Academic Press, Washington, D.C., p 293–321

Biggs R, Simons H, Bakkenes M et al. (2008) Scenarios of biodiversity loss in southern Africa in the 21st century. Glob Environ Chang 18:296–309. https://doi.org/10.1016/j.gloenvcha.2008.02.001

Blaikie P (2006) Is small really beautiful? Community-based natural resource management in Malawi and Botswana. World Dev 34:1942–1957. https://doi.org/10.1016/j.worlddev.2005.11.023

Blaikie P, Brown K, Stocking M et al. (1997) Knowledge in action: local knowledge as a development resource and barriers to its incorporation in natural resource research and development. Agric Syst 55:217–237. https://doi.org/10.1016/S0308-521X(97)00008-5

Bouwen R, Taillieu T (2004) Multi-party collaboration as social learning for interdependence: developing relational knowing for sustainable natural resource management. J Community Appl Soc Psychol 14:137–153. https://doi.org/10.1002/casp.777

Cash DW, Clark WC, Alcock F et al. (2003) Knowledge systems for sustainable development. Proc Natl Acad Sci USA 100:8086–8091. https://doi.org/10.1073/pnas.1231332100

CMP (The Conservation Measures Partnership) (2013) Open standards for the practice of conservation, Version 3. CMP, Washington, D.C.

Cooke B, Kothari U (2001) Participation: the new tyranny? Zed Books, London, UK and New York, NY
de Wit M, Stankiewicz J (2006) Changes in surface water supply across Africa with predicted climate change. Science (80-) 311:1917–1921. https://doi.org/10.1126/science.1119929
Díaz S, Demissew S, Carabias J et al. (2015) The IPBES conceptual framework — connecting nature and people. Curr Opin Environ Sustain 14:1–16. https://doi.org/10.1016/j.cosust.2014.11.002
Dirkx E, Hager C, Tadross M et al. (2008) Climate change vulnerability & adaptation assessment Namibia. Desert Research Foundation of Namibia & Climate Systems Analysis Group, Windhoek, Namibia
Escobar A (1998) Whose knowledge whose nature? Biodiversity conservation and the political ecology of social movements. J Polit Ecol 5:53–82
Falk T (2008) Communal farmers' natural resource use and biodiversity preservation: a new economic analysis from case studies in Namibia and South Africa. Cuvillier, Göttingen, Germany
Field CB, Barros VR, Mastrandrea MD et al. (2014) Summary for policy makers. In: Field CB, Barros VR, Dokken DJ, et al. (eds) Climate change 2014: impacts, adaptation and vulnerability - contributions of the working group II to the fifth assessment report. Cambridge University Press, Cambridge, UK and New York, NY, p 1–32
Funder M, Ngaga Y, Nielsen M et al. (2013) Reshaping conservation: the social dynamics of participatory monitoring in Tanzania′s community-managed forests. Conserv Soc 11:218. https://doi.org/10.4103/0972-4923.121011
Gagnon CA, Berteaux D (2009) Integrating traditional ecological knowledge and ecological science: a question of scale. Ecol Soc 14:19
Government of Namibia (2002) Initial national communication to the United Nations Framework Convention on Climate Change. Ministry of Environment and Tourism, Windhoek, Namibia, p 79
Haywood BK, Parrish JK, Dolliver J (2016) Place-based and data-rich citizen science as a precursor for conservation action. Conserv Biol 30:476–486. https://doi.org/10.1111/cobi.12702
Hill R, Pert PL, Davies J et al. (2013) Indigenous land management in Australia: extent, scope, diversity, barriers and success factors. CSIRO Ecosystem Sciences, Cairns, Australia
Hudson D, Jones R (2002) Regional climate model simulations of present-day and future climates of southern Africa. Hadley Centre for Climate Prediction and Research, Bracknell, UK
Hulme M, Doherty R, Ngara T et al. (2001) African climate change: 1900-2100. Clim Res 17:145–168. https://doi.org/10.3354/cr017145
Huntington HP (2000) Using traditional ecological knowledge in science: methods and applications. Ecol Appl 10:1270–1274
Hüttich C (2011) Mapping vegetation types in a Savanna ecosystem in Namibia: concepts for integrated land cover assessments. Friedrich-Schiller-University, Jena, Germany
Ibisch PL, Hobson P (2014) MARISCO: adaptive MAnagement of vulnerability and RISk at COnservation sites. Centre for Econics and Ecosystem Management, Eberswalde, Germany, www.marisco.training
Ibisch PL, Hobson P, Krause A et al. (2015) Great Altay Transboundary Biosphere Reserve. Development of a management plan of the proposed Great Altay Transboundary Biosphere Reserve, Republic of Kazakhstan and Russian Federation. Centre for Econics and Ecosystem Management, Eberswalde, Germany
Ibisch PL, Hobson PR (2012) Blindspots and sustainability under global change: non-knowledge illiteracy as a key challenge to a knowledge society. In: Ibisch PL, Geiger L, Cybulla F (eds) Global change management: knowledge gaps, blindspots and unknowables. Nomos, Baden-Baden, Germany, p 15–54
Ibisch PL, Hobson PR (2015) Lessons from case studies applying the MARISCO approach. Centre for Econics and Ecosystem Management, Eberswalde, Germany
Jiao Y, Li X, Liang L et al. (2012) Indigenous ecological knowledge and natural resource management in the cultural landscape of China's Hani Terraces. Ecol Res 27:247–263. https://doi.org/10.1007/s11284-011-0895-3
Kahler JS, Roloff GJ, Gore ML (2013) Poaching risks in community-based natural resource management. Conserv Biol 27:177–186. https://doi.org/10.1111/j.1523-1739.2012.01960.x
Khumalo K, Yung L (2015) Women, human-wildlife conflict, and CBNRM: hidden impacts and vulnerabilities in Kwandu Conservancy, Namibia. Conserv Soc 13:232. https://doi.org/10.4103/0972-4923.170395
Kimmerer RW (2002) Weaving traditional ecological knowledge into biological education: a call to action. Bioscience 52:432. https://doi.org/10.1641/0006-3568(2002)052[0432:WTEKIB]2.0.CO;2
Kothari U (2001) Power, knowledge and social control in participatory development. In: Cooke B, Kothari U (eds) Participation the new tyranny. Zed Books, London, UK and New York, NY, p 139–152
Laidler GJ (2006) Inuit and scientific perspectives on the relationship between sea ice and climate change: the ideal complement? Clim Change 78:407–444. https://doi.org/10.1007/s10584-006-9064-z
Langton M, Rhea ZM, Palmer L (2005) Community-oriented protected areas for indigenous peoples and local communities. J Polit Ecol 12:23. https://doi.org/10.2458/v12i1.21672
Leite MCF, Gasalla MA (2013) A method for assessing fishers' ecological knowledge as a practical tool for ecosystem-based fisheries management: seeking consensus in Southeastern Brazil. Fish Res 145:43–53. https://doi.org/10.1016/j.fishres.2013.02.013
Lobell DB, Burke MB, Tebaldi C et al. (2008) Prioritizing climate change adaptation needs for food security in 2030. Science (80-) 319:607–610. https://doi.org/10.1126/science.1152339
Mendelsohn J (2005) Forests and Woodlands of Namibia. Directorate of Forestry; Ministry of Agriculture, Water and Forestry, Windhoek, Namibia
Mendelsohn J, el Obeid S (2003) Sand and water - a profile of the Kavango region. Struik, Cape Town, South Africa
Mendelsohn J, el Obeid S (2004) Okavango river - the flow of a lifeline. Struik & RAISON, Cape Town, South Africa and Windhoek, Namibia
Mercer J, Kelman I, Alfthan B, Kurvits T (2012) Ecosystem-based adaptation to climate change in Caribbean small island developing states: integrating local and external knowledge. Sustainability 4:1908–1932. https://doi.org/10.3390/su4081908
Midgley G, Hughes G, Thuiller W et al. (2005) Assessment of potential climate change impacts on Namibia's floristic diversity, ecosystem structure and function. Climate Change Research Group, South African National Biodiversity Institute, Cape Town, South Africa
Mosse D (2001) 'People's knowledge´, participation and patronage: operations and representations in rural development. In: Cooke B, Kothari U (eds) Participation the new tyranny. Zed Books, London, UK and New York, NY, p 16–35
NACSO (2009a) Conservancy profile. George Mukoya Conservancy. Namibia Association of CBNRM Support Organizations, Windhoek, Namibia
NACSO (2009b) Conservancy profile. Muduva Nyangana Conservancy. Namibia Association of CBNRM Support Organizations, Windhoek, Namibia
NACSO (2012) Living with wildlife - the story of Khaudum North Complex. Namibia Association of CBNRM Support Organizations. Windhoek, Namibia
NACSO (2016) The state of community conservation in Namibia — a review of communal conservancies, community forests and other

CBNRM initiatives (2015 Annual Report). Namibia Association of CBNRM Support Organizations, Windhoek, Namibia
Naidoo R, Weaver LC, De Longcamp M, Du Plessis P (2011) Namibia's community-based natural resource management programme: an unrecognized payments for ecosystem services scheme. Environ Conserv 38:445–453. https://doi.org/10.1017/S0376892911000476
Naidoo R, Weaver LC, Diggle RW et al. (2016) Complementary benefits of tourism and hunting to communal conservancies in Namibia. Conserv Biol 30:628–638. https://doi.org/10.1111/cobi.12643
Nel JL, Roux DJ, Driver A et al. (2016) Knowledge co-production and boundary work to promote implementation of conservation plans. Conserv Biol 30:176–188. https://doi.org/10.1111/cobi.12560
Nielsen M, Lund J (2012) Seeing white elephants? The production and communication of information in a locally-based monitoring system in Tanzania. Conserv Soc 10:1. https://doi.org/10.4103/0972-4923.92188
Nightingale A (2003) Nature–society and development: social, cultural and ecological change in Nepal. Geoforum 34:525–540. https://doi.org/10.1016/S0016-7185(03)00026-5
Nuijten M (2005) Power in practice: a force field approach to natural resource management. Transdiscipl Environ Stud 4:1–14
Pauly D (1995) Anecdotes and the shifting baseline syndrome of fisheries. Trends Ecol Evol 10:430. https://doi.org/10.1016/S0169-5347(00)89171-5
Pretty J, Ward H (2001) Social capital and the environment. World Dev 29:209–227. https://doi.org/10.1016/S0305-750X(00)00098-X
Pröpper M (2009a) Culture and biodiversity in Central Kavango, Namibia. Dietrich Reimer Verlag, Berlin, Germany
Pröpper M (2009b) Sawing Kavango timber commons levels of action and agency upon local natural capital. In: Greiner C, Kokot W (eds) Networks, resources and economic action. Ethnographic case studies in honor of Hartmut Lang. Dietrich Reimer Verlag, Berlin, Germany, p 171–188
R Core Team (2016) R: a language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria, https://www.R-project.org/ doi: ISBN 3-900051-07-0
Raymond CM, Fazey I, Reed MS et al. (2010) Integrating local and scientific knowledge for environmental management. J Environ Manag 91:1766–1777. https://doi.org/10.1016/j.jenvman.2010.03.023
Reid H, Sahlen L, Stage J, MacGregor J (2007) The economic impact of climate change in Namibia: How climate change will affect the contribution of Namibia's natural resources to its economy. Environmental Economics Programme Discussion Paper 07-02. International Institute for Environment and Development, London, United Kingdom
Reid WV, Berkes F, Wilbanks T, Capistrano D (eds) (2006) Bridging scales and knowledge systems - concepts and applications in ecosystem assessment. Island Press, Washington, D.C.
Reyes-Garcia V, Ruiz-Mallen I, Porter-Bolland L et al. (2013) Local understandings of conservation in southeastern Mexico and their implications for community-based conservation as an alternative paradigm. Conserv Biol 27:856–865. https://doi.org/10.1111/cobi.12056
Rieprich R, Schnegg M (2015) The value of landscapes in Northern Namibia: a system of intertwined material and nonmaterial services. Soc Nat Resour 28:941–958. https://doi.org/10.1080/08941920.2015.1014598
Röder A, Pröpper M, Stellmes M et al. (2016) Assessing urban growth and rural land use transformations in a cross-border situation in Northern Namibia and Southern Angola. Land Use Policy 53:97–111. https://doi.org/10.1016/j.landusepol.2014.08.020
Roturier S, Roué M (2009) Of forest, snow and lichen: Sámi reindeer herders' knowledge of winter pastures in northern Sweden. Ecol Manag 258:1960–1967. https://doi.org/10.1016/j.foreco.2009.07.045
Salafsky N, Salzer D, Stattersfield AJ et al. (2008) A standard lexicon for biodiversity conservation: unified classifications of threats and actions. Conserv Biol 22:897–911. https://doi.org/10.1111/j.1523-1739.2008.00937.x
Salvaterra T, Allenbach K, Hobson P et al. (2016) Exploring the potential of ecosystem-based approaches – ecosystem-based adaptation and ecosystem-based disaster risk reduction. In: Policy brief with proceedings from a PLACARD session convened as part of the 4th Adaptation Futures Conference. 10–13 May, Rotterdam, The Netherlands, p 1–4
Sam H, Giles M (2005) Relocating participation within a radical politics of development Development and Change 36(2):237–262
Santos de Aquino A, Bocarde F, Aparecida de Souza Lima N, Ruffino ML (2007) Participative management of fishing resources in the Amazon. In: Prates AP, Blanc D (eds) Participative management of fishing resources in the Amazon. ProVárzea/Ibama, Manaus, Brazil, p 213–233
Sarvimäki A (2006) Well-being as being well—a Heideggerian look at well-being. Int J Qual Stud Health Well-Being 1:4–10. https://doi.org/10.1080/17482620500518101
Satterfield T, Kandlikar M, Beaudrie CEH et al. (2009) Anticipating the perceived risk of nanotechnologies. Nat Nanotechnol 4:752–758. https://doi.org/10.1038/nnano.2009.265
Schick A, Hobson PR, Ibisch PL (2017) Conservation and sustainable development in a VUCA world: the need for a systemic and ecosystem-based approach Ecosyst Heal Sustain 3:e01267. https://doi.org/10.1002/ehs2.1267
Schmink M, Wood CH (1992) Contested frontiers in Amazonia. Columbia University Press, New York, NY
Schnegg M, Rieprich R, Pröpper M (2014) Culture, nature, and the valuation of ecosystem services in northern Namibia. Ecol Soc 19:art26. https://doi.org/10.5751/ES-06896-190426
Scholes RJ, Biggs R (2004) Ecosystem services in Southern Africa: a regional assessment. Council for Scientific and Industrial Research, Pretoria, South Africa
Schreiber ESG, Bearlin AR, Nicol SJ, Todd CR (2004) Adaptive management: a synthesis of current understanding and effective application. Ecol Manag Restor 5:177–182. https://doi.org/10.1111/j.1442-8903.2004.00206.x
Secretariat of the Convention on Biological Diversity (ed) (2004) The ecosystem approach, (CBD Guidelines). Secretariat of the Convention on Biological Diversity, Montreal, Canada
Selfa T, Endter-Wada J (2008) The politics of community-based conservation in natural resource management: a focus for International Comparative Analysis. Environ Plan A 40:948–965. https://doi.org/10.1068/a39160
Sheeran J (2008) The challenge of hunger. Lancet 371:180–181. https://doi.org/10.1016/S0140-6736(07)61870-4
Staddon SC, Nightingale A, Shrestha SK (2015) Exploring participation in ecological monitoring in Nepal's community forests. Environ Conserv 42:268–277. https://doi.org/10.1017/S037689291500003X
Star SL, Griesemer JR (1989) Institutional ecology, "translations" and boundary objects: amateurs and professionals in Berkeley's Museum of Vertebrate Zoology, 1907-39. Soc Stud Sci 19:387–420
Stellmes M, Frantz D, Finckh M, Revermann R (2013) Okavango basin - earth observation. Biodivers Ecol 5:23–27. https://doi.org/10.7809/b-e.00239.23
Strohbach BJ (2013) Vegetation of the Okavango river valley in Kavango West, Namibia. Biodivers Ecol 5:321–339. https://doi.org/10.7809/b-e.00286.321

Strohbach BJ, Petersen A (2007) Vegetation of the central Kavango woodlands in Namibia: an example from the Mile 46 Livestock Development Centre. South Afr J Bot 73:391–401. https://doi.org/10.1016/j.sajb.2007.03.002

Tengö M, Brondizio ES, Elmqvist T et al. (2014) Connecting diverse knowledge systems for enhanced ecosystem governance: the multiple evidence base approach. Ambio 43:579–591. https://doi.org/10.1007/s13280-014-0501-3

Tengö M, Hill R, Malmer P et al. (2017) Weaving knowledge systems in IPBES, CBD and beyond—lessons learned for sustainability. Curr Opin Environ Sustain 26–27:17–25. https://doi.org/10.1016/j.cosust.2016.12.005

Tengö M, Malmer P, Brondazio E et al. (2013) The multiple evidence base as a framework for connecting diverse knowledge systems in the IPBES. Stockholm Resilience Centre (SRC), Stockholm, Sweden

Thaman R, Lyver P, Pérez E et al. (2013) The contribution of indigenous and local knowledge systems to IPBES: building synergies with science. United Nations Educational, Scientific and Cultural Organization, Paris, France

Treves A, Andriamampianina L, Didier K et al. (2006) A simple, cost-effective method for involving stakeholders in spatial assessments of threats to biodiversity. Hum Dimens Wildl 11:43–54. https://doi.org/10.1080/10871200500470993

Tschakert P, Das PJ, Shrestha Pradhan N et al. (2016) Micropolitics in collective learning spaces for adaptive decision making. Glob Environ Chang 40:182–194. https://doi.org/10.1016/j.gloenvcha.2016.07.004

Tschakert P, van Oort B, St. Clair AL, LaMadrid A (2013) Inequality and transformation analyses: a complementary lens for addressing vulnerability to climate change. Clim Dev 5:340–350. https://doi.org/10.1080/17565529.2013.828583

Tschirhart C, Mistry J, Berardi A et al. (2016) Learning from one another: evaluating the impact of horizontal knowledge exchange for environmental management and governance. Ecol Soc 21:41. https://doi.org/10.5751/ES-08495-210241

Turpie AJ, Midgley G, Brown C et al. (2010) Climate change vulnerability and adaptation assessment for Namibia's biodiversity and protected area system. Anchor Environmental Consultants, Tokai, South Africa, Nambia Nature Foundation and South African Institute for Environmental Assessment, Windhoek, Namibia

Vera FWM (2009) Large-scale nature development - the Oostvaardersplassen Br Wildl 20:28–36

Vogel M (2006) Erfassung von Vegetationsveränderungen in Namibia mit Hilfe von Fernerkundungs-Change-Detection-Verfahren und unter Berücksichtigung rezenter Niederschlagsereignisse. Julius-Maximilians-Universität Würzburg, Germany

Waylen KA, Martin-Ortega J, Blackstock KL et al. (2015) Can scenario-planning support community-based natural resource management? Experiences from three countries in Latin America. Ecol Soc 20:Art 28. https://doi.org/10.5751/ES-07926-200428

Webler T, Tuler S, Krueger R (2001) What is a good public participation process? Five perspectives from the public. Environ Manag 27:435–450. https://doi.org/10.1007/s002670010160

Wollenberg E, Nawir AA, Uluk A, Pramono H (2001) Income is not enough: the effect of economic incentives on forest product conservation: a comparison of forest communities dependent on the agroforests of Krui, Sumatra and natural dipterocarp forests of Kayan Mentarang, East Kalimantan. Center for International Forestry Research (CIFOR), Bogor, Indonesia

Woodward FI, Lomas MR (2004) Simulating vegetation processes along the Kalahari transect. Glob Chang Biol 10:383–392. https://doi.org/10.1046/j.1365-2486.2003.00697.x