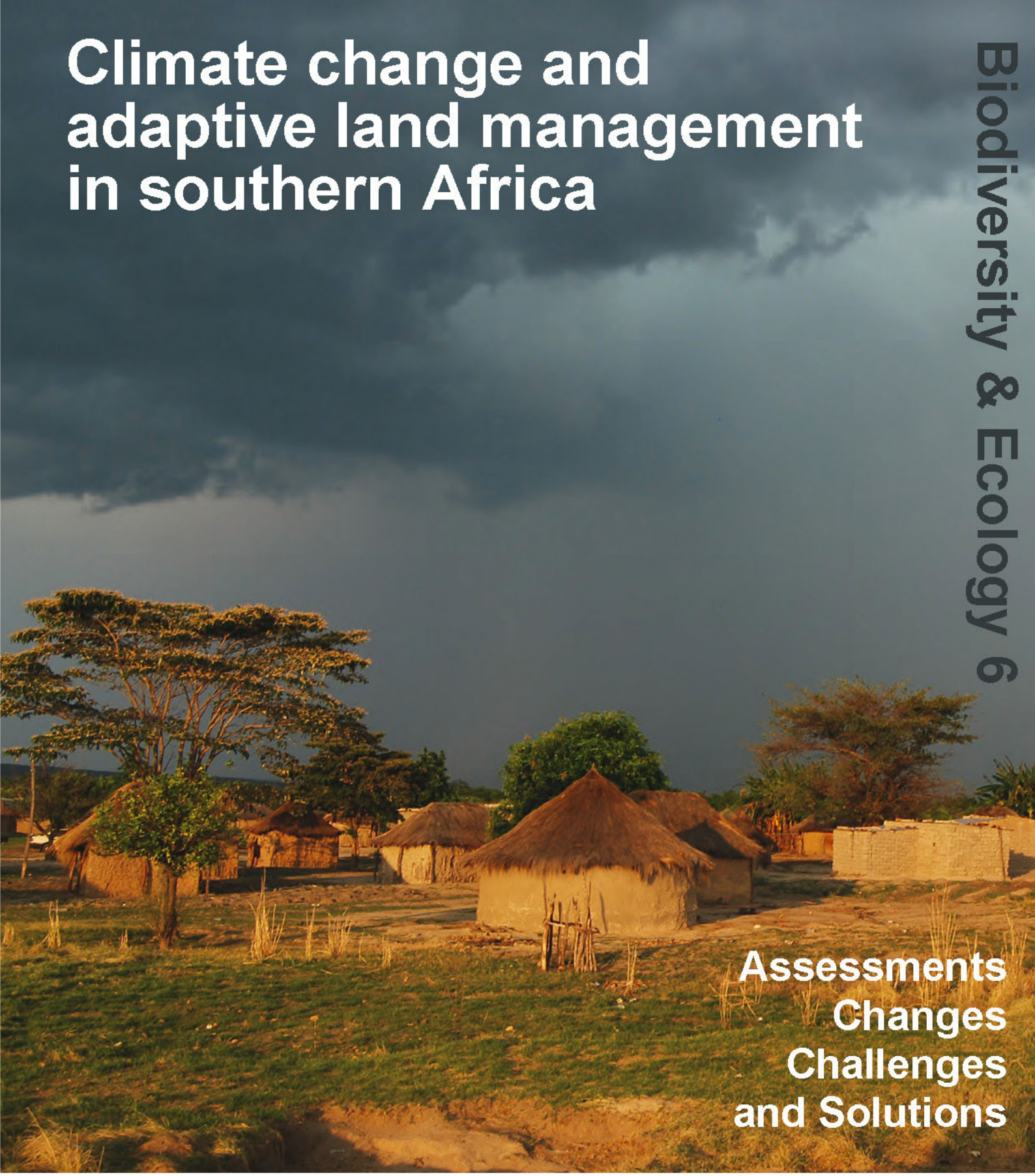
Climate change and adaptive land management in southern Africa

Biodiversity & Ecology 6



Assessments Changes Challenges and Solutions

Product of the first research portfolio of

SASSCAL 2012–2018

Southern African Science Service Centre for Climate Change and Adaptive Land Management

SPONSORED BY THE

Federal Ministry of Education and Research

Klaus Hess Publishers
Göttingen & Windhoek
www.k-hess-verlag.de

ISBN: 978-3-933117-95-3 (Germany), 978-99916-57-43-1 (Namibia)

Language editing: Will Simonson (Cambridge), and Proofreading Pal
Translation of abstracts to Portuguese: Ana Filipa Guerra Silva Gomes da Piedade
Page desing & layout: Marit Arnold, Klaus A. Hess, Ria Henning-Lohmann
Cover photographs:
front: Thunderstorm approaching a village on the Angolan Central Plateau (Rasmus Revermann)
back: Fire in the miombo woodlands, Zambia (David Parduhn)
Cover Design: Ria Henning-Lohmann

ISSN 1613-9801

Printed in Germany

Suggestion for citations:
Volume:
Revermann, R., Krewenka, K.M., Schmiedel, U., Olwoch, J.M., Helmschrot, J. & Jürgens, N. (eds.) (2018) Climate change and adaptive land management in southern Africa – assessments, changes, challenges, and solutions. *Biodiversity & Ecology*, **6**, Klaus Hess Publishers, Göttingen & Windhoek.

Articles (example):
Archer, E., Engelbrecht, F., Hänsler, A., Landman, W., Tadross, M. & Helmschrot, J. (2018) Seasonal prediction and regional climate projections for southern Africa. In: *Climate change and adaptive land management in southern Africa – assessments, changes, challenges, and solutions* (ed. by Revermann, R., Krewenka, K.M., Schmiedel, U., Olwoch, J.M., Helmschrot, J. & Jürgens, N.), pp. 14–21, *Biodiversity & Ecology*, **6**, Klaus Hess Publishers, Göttingen & Windhoek.

Corrections brought to our attention will be published at the following location:
http://www.biodiversity-plants.de/biodivers_ecol/biodivers_ecol.php

Biodiversity & Ecology

Journal of the Division Biodiversity, Evolution and Ecology of Plants,
Institute for Plant Science and Microbiology, University of Hamburg

Volume 6:

Climate change and adaptive land management in southern Africa

Assessments, changes, challenges, and solutions

Edited by

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Hamburg 2018

Please cite the article as follows:

Winter, E., Gronau, S. & Grote, U. (2018) Sustaining rural livelihoods through an integrated landscape approach. In: *Climate change and adaptive land management in southern Africa – assessments, changes, challenges, and solutions* (ed. by Revermann, R., Krewenka, K.M., Schmiedel, U., Olwoch, J.M., Helmschrot, J. & Jürgens, N.), pp. 288-294, *Biodiversity & Ecology*, **6**, Klaus Hess Publishers, Göttingen & Windhoek. doi:10.7809/b-e.00336

Sustaining rural livelihoods through an integrated landscape approach

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Abstract: Our socioeconomic field studies in the Zambezi region of Namibia show that the agricultural system is characterized by extremely low diversity, not providing sufficient nutrients to ensure food security for a growing population. We find that programs to protect wildlife and forests are not harmonizing well with smallholder farming. While politicians and external stakeholders pay attention to biodiversity in protected areas, they largely ignore agrobiodiversity. Agricultural policy in particular is more likely to limit resilient landscape development, as shown, for example, by targeted subsidies for maize cultivation. Regarding the much-discussed link between development and conservation, existing approaches such as community-based natural resource management (CBNRM) and joint management of fisheries resources do not take due account of the importance of benefit sharing and food security. The economic incentives provided by these systems in the form of hunting quotas or recreational angling operations neither are sufficient to halt the progressive loss of biodiversity nor offer alternatives to the exploitation of natural resources on which the local population highly depends. The paper discusses selected research findings and suggests a more holistic approach to landscape management.

Resumo: Os nossos estudos socio-económicos na região do Zambezi, Namíbia, mostram que o sistema agrícola é caracterizado por uma diversidade extremamente baixa, não fornecendo nutrientes suficientes para assegurar a segurança alimentar de uma população em crescimento. Verificamos que os programas para a protecção da vida selvagem e florestas não estão a harmonizar bem com a agricultura de subsistência. Enquanto que os políticos e as partes interessadas externas prestam atenção à biodiversidade em áreas protegidas, estes ignoram em grande parte a agrobiodiversidade. A política agrícola em particular tem maior probabilidade de limitar o desenvolvimento de paisagens resilientes, tal como visto, por exemplo, nos subsídios direccionados para o cultivo do milho. Quanto à muito discutida ligação entre o desenvolvimento e a conservação, as abordagens existentes, tais como a Gestão de Recursos Naturais Comunitários (CBNRM) e a gestão conjunta dos recursos piscatórios, não têm em conta a importância da partilha de benefícios e a segurança alimentar. Os incentivos económicos oferecidos por estes sistemas sob a forma de quotas de caça ou operações de pesca recreativa, não são suficientes para travar a perda progressiva da biodiversidade, nem oferecem alternativas para a exploração dos recursos naturais, dos quais a população local está altamente dependente. O artigo discute determinados resultados da investigação e sugere uma abordagem mais holística para a gestão da paisagem.

Introduction

The SASSCAL region hosts farming systems habitually consisting of mosaics of cleared farming land, forests, and water bodies, together providing multiple ecosystem services to heterogeneous groups of stakeholders. Various forms of community involvement in fisheries, forestry, and wildlife management have developed in the region. Despite the popularity of community-based programs, however, the overall impact of communities' natural resource management on rural development and the natural environment remains unclear (Humavindu & Stage, 2015; Lewins et al., 2014; Riehl et al., 2015; Silva & Mosimane, 2012). Whereas in some regions of Namibia wildlife populations have increased and tourism is developing (Naido et al., 2016), drastic declines in wildlife populations are occurring in Zambia's game management areas as a result of poaching and escalating land use conflicts (Duffy & Humphreys, 2017; Nyirenda et al., 2017). Human-wildlife conflicts are also reported for villages in Botswana and conservancies in northern Namibia. Women-headed households are particularly affected by high crop losses caused by migrating herds of elephants, as they have less access to compensation and receive little help because of their low status (Gupta, 2013; Khumalo & Yung, 2015). As a result, it is controversially debated whether resources in the region should be used primarily for food production, for nature conservation purposes, or even to promote the coexistence of wildlife and livestock (FAO, 2017; Fynn et al., 2016).

Similar conflicts of interest over the use of natural resources for food or their protection for the benefit of tourism also exist in the field of fisheries management (Abbott et al., 2007; Tweddle et al., 2015). Fish stocks, located in the Zambezi River and across the floodplains in the Zambezi Region, suffer from overfishing and a lack of coordinated management with cross-border Zambia. Conservation efforts in one country, such as establishing protected breeding areas for fish, are often undermined by activities in the other country. Little is also yet known about the status of inland fishing in sub-Saharan Africa and the contribution of small fish, known as 'kapenta' or 'chisense', to the diets of local people. Small fish, sundried and eaten whole, make a very important contribution to a healthy diet, but they are hardly included in the catch statistics (Kolding et al., 2016a; Kolding et al., 2016b). There are, however, controversial views on appropriate management; whereas some experts advocate the management of individual species (e.g., by means of catch controls and selective fishing), other scientists see the need for habitat protection and balanced fishing (e.g., the conservation of wetlands and floodplains as the most productive aquatic systems, where fish come with the rains).

A general problem of natural resource management is the division of responsibilities for different resources among different authorities, particularly the legislative separation between hunting, fishing, and farming (Kolding et al., 2016b). Emerging research on social-ecological systems (SES) has advocated the shift of resource management away from segregated top-down control measures towards integrated, dynamically responsive approaches aimed at improving the resilience of whole landscapes through softer, less intrusive interventions (Daron et al., 2015; Ostrom, 2013).

In Namibia, we observe that the livelihoods of individual households in most cases depend on a mixture of agriculture, extraction of forest products, and fisheries. Households use the diverse services of the ecosystem to manage permanent risks of crop failure and food insecurity. Yet interventions addressing nutrition security and poverty elimination do not usually take a cross-sectoral approach (De Leon et al., 2016; Fisher et al., 2017). Instead, landscape concepts have become the focus of interest in reconciling nature conservation and rural development by looking at landscape conservation from a people-oriented perspective (Denier et al., 2015; Sayer et al., 2013). In addition, a growing number of publications deal with landscape governance issues (see, for example, Foli et al., 2017; Kozar et al., 2014; Mallet et al., 2016; Reed et al., 2016).

The landscape approach

Unlike a sector perspective, an integrated or multifunctional landscape approach recognizes the complex dynamic processes occurring in a landscape. Considering the complexity and the unpredictable nature of SES, key elements of a landscape approach include adaptive management and learning, multi-stakeholder negotiations, capacity-building knowledge platforms, participatory monitoring, and a transparent pathway of change (Allen & Garmestani, 2015; Reed et al., 2016). Critical barriers to its implementation have been identified in areas of low-cost monitoring and sound impact evaluation (Reed et al., 2016). More empirical research on behavioural theory and decision-making can help to understand adoption processes and better map human behaviour in computer-based SES models (Anderies et al., 2011; Schlüter et al., 2017). A further important research issue in the context of landscape management concerns the development of participatory tools for increasing stakeholders' engagement in landscape governance and reducing imbalances in knowledge and power (Kozar et al., 2014). In this respect, tools such as participatory mapping, behavioural experiments, and role-playing games gain in importance and subsequently provide information to more formal computer-based models,

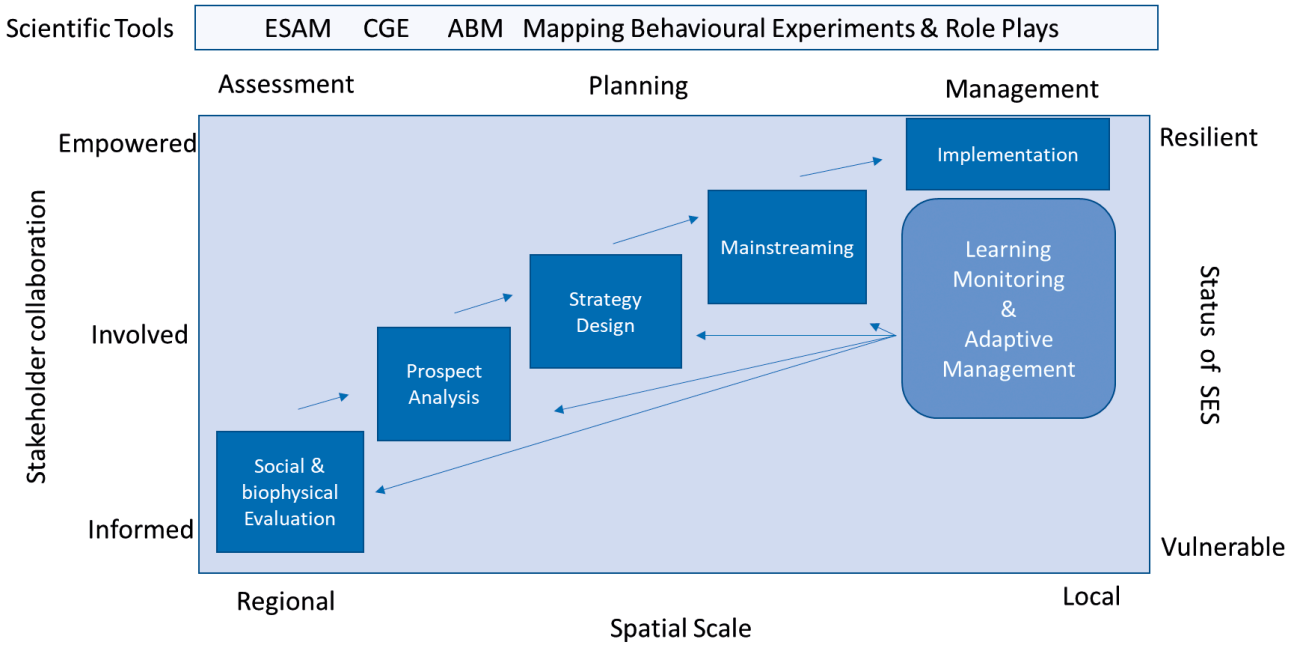

Figure 1: Pathway for implementing an integrated landscape management approach. Source: own figure based on Cowling et al. (2008).

Figure 2: Role play in a community meeting (a); participatory mapping with a women's group (b). Source: own pictures

which in turn can advise decision-making (Perrotton et al., 2017; Purnomo et al., 2009; Röttgers, 2016; Salvini et al., 2016; Speelman et al., 2014; Villamore et al., 2014).

To understand the challenges of sustainable land use management and address the issue of fair benefit sharing, we applied a set of participatory tools combined with econometric and numerical simulation models. Empirical research reveals that participatory tools facilitate the development of a broader knowledge system through combining traditional and science-based knowledge in a network (Kozar et al., 2014; Scholz et al., 2014). Figure 1 shows a pathway of an integrated landscape approach to managing an SES based on Cowling et al. (2008), who aimed to develop an operational model to implement effective on-the-ground management. The model relies on the findings of numerous empirical studies (see, for example, Foli et al., 2017; Frost et al., 2006).

The scientific tool box depicted in the upper part of the figure shows the methods we applied in our study. These tools comprise environmental social accounting (ESA), computable general equilibrium (CGE) modelling, agent-based modelling (ABM), mapping, behavioural experiments, and role plays. The tools are associated with the three steps of implementing the pathway of a landscape approach comprising assessment, planning, and management. The use of different tools offers advantages for comprehensive research but is of course time-consuming and requires interdisciplinary and transdisciplinary cooperation. Participatory tools, however, are the central component if awareness building and co-management are the goals. Selected methods and results of our research are explained in the following section.

Data and field research

The field studies were conducted in the Sikunga Conservancy, a developing conservancy gazetted in 2009 and located in the Zambezi Region of Namibia. The conservancy covers an area of 287 km^2 which is dominated by floodplains and Mopane woodlands (Mendelsohn, 2010). The region belongs to the Kavango-Zambezi Transfrontier Conservation Area (KAZA TFCA) and is home to rich wildlife and valuable freshwater fish resources (Tweddle et al., 2018). However, the Zambezi Region also suffers from high levels of poverty, malnutrition and income inequality. Moreover, the lack of coordinated management has resulted in an ongoing decrease in livelihoods through deforestation, slash-and-burn cultivation, eroding grazing plains, poaching, and overfishing (Abbott et al., 2009; Tweddle et al., 2015). From approximately 440 households living in 6 villages, 200 households (45%) were randomly sampled in 2012. The survey covered all economic activities with a focus on the collection, consumption, and trade of natural resources and on the nutritional status of the households.

The data were used to construct an environmental social accounting matrix (ESAM) for the study region (Morton et al., 2016). The ESAM is a specification of the System of Environmental and Economic Accounting (SEEA; UNSTAT, 2016) and plays an important role in policy planning and monitoring (Angelsen et al., 2014; De Anguita & Wagner, 2010). The developed matrix represents the total economic transactions within the Sikunga Conservancy for a single year and displays the linkages between economic activities and changes in natural capital in one table. Depending on the research questions, different subregions, sectors, and household groups can be depicted in separate accounts to derive the impact of

Table 1: Nutrition state and household income of the four clustered household groups. Source: own calculations

Daily nutrient intake per adult person per day	Daily minimum requirement	Household group 1 subsistance farmers (deficit in %)	Household group 2 fish & forest users (deficit in %)	Household group 3 skilled off-farm workers (deficit in %)	Household group 4 senior members (deficit in %)
Energy (kcal)	2100	-25.7	-16.6	-26.3	-3.2
Fat (g)	40	-9.3	-2.4	-6.4	33.2
Iodine (μg)	150	-79.9	-50.6	-83.0	-39.0
Iron (μg)	22	-42.4	-34.7	-46.4	-29.8
Protein (g)	52	-13.2	27.7	-46.8	43.5
Vitamin A (μg)	500	-59.1	-52.8	-62.3	-33.4
Zinc (mg)	12	-42.3	-27.5	-44.9	-17.8
Total Income (1000 NAD per household & year)					
1€=10NAD in 2012		14.7	24.2	58.9	23.5
Income from:					
Agriculture %		13.4	11.0	10.1	6.7
Fish resources %		5.8	31.2	0.4	2.7
Forest resources %		15.9	10.8	5.9	2.6
Off-farm employment %		43.0	34.0	81.0	38.9
Welfare payments and remittances %		21.9	13.0	2.7	49.1

specific production techniques and different livelihood strategies on the environment. We identify four household groups that differ in terms of their income, consumption, and nutrition situations. The combined representation of monetary and physical accounts within a single matrix is a useful feature to portray the SES of Sikunga Conservancy. In a second research task, the ESAM provides the basic data structure for the design of more advanced socioeconomic simulation models (Gronau et al., 2017). One of the models we have developed is a CGE model that facilitates impact evaluation of different policy interventions. One specification of the model was used to analyse the effect of recreational angling tourism in combination with more restricted fishing policies on freshwater fish stocks and the livelihoods of local households. In further model scenarios, we evaluated a set of agro-ecological food system interventions. In addition to ESAM and CGE analyses, several focus group meetings, behavioural experiments, and role-plays (Fig. 2) have been organized to initiate discussions on sustainable landscape management among community members (Röttgers, 2016; Winter et al., 2017).

Finally, an ABM has been designed to give a picture of current land use activities in the study region and to simulate effects of newly introduced agricultural practices such as agroforestry with *Faidherbia albida*, a nitrogen-fixing tree (Koch, 2017). An ABM has very useful properties for outlining phenomena of emergence in complex social-ecological systems (Moritz et al., 2015; Schlüter et al., 2017). They are well suited for analysing the interaction of heterogeneous agents within a system at different levels of their actions or decision-making processes.

Results and discussion

The ESAM provides valuable insights into the economic and environmental linkages of CBNRM outcomes in the study region. Moreover, the regional representation of the villages in the ESAM framework makes the tool particularly useful in supporting landscape planning. We find that economic output produced from natural resource extraction and harvesting in Sikunga Conservancy is almost double that of both agriculture and all off-farm activities together. With an average yield of 360 kg of maize per hectare, however, the current agricultural system cannot produce even the basic foodstuffs it needs. Up to 80% of individual nutrients are missing in the daily diets, and malnutrition is a serious regional problem. Looking more closely at the nutrition state, consumption analysis at the household level has shown that economic development is not necessarily accompanied by an improvement in nutrition and a more balanced distribution of food in households (Tab. 1). This result is consistent with studies from other countries in sub-Saharan Africa (Brown et al., 2017; Burroway, 2016). Table 1 furthermore shows that household income varies widely at a very low level in absolute terms. All households are below (groups 1, 2, and 4) or just above (group 3) the poverty threshold of US$1.25 per capita per day.

The analysis further reveals that fish resources are harvested at unsustainable rates and slash-and-burn practices destroy about a third of the value of annual growth in forest stocks (Morton et al., 2016). All natural resource–based sectors are strongly interconnected, meaning that bundles of natural resources such as thatching grass, firewood, and fish secure local livelihoods. Opposed to the nature-based sectors, the rest of the economy, particularly off-farm employment in the public sector, is growing separately and somewhat disconnected, missing notable trickle-down effects. This indicates that the growing prosperity of relatively wealthier households is not gradually transferring to the poor. The result has meaningful implications for community development and once more underscores the need for an integrated landscape management approach.

Although CBNRM is a governance conception aiming to deliver locally adapted sustainable and equitable rural development (Fabricius et al., 2013), our analysis, which is in line with Mosimane and Silva (2015), reveals that Namibian conservancies have not yet developed fair and transparent benefit-sharing systems. A decisive factor for failure is that biased income allocation in favour of asset-rich households causes unsustainable increases in cattle stocks and growing demand for grazing land coupled with increased deforestation. Our analysis confirms the argument of Barendse et al. (2016) that an important limiting factor of CBNRM success is the government's inadequate implementation capacity, implying that local stakeholders have limited opportunities to develop natural resource stewardship. An operational landscape approach therefore requires a multiple-scales polycentric governance architecture as proposed by Ostrom (2012).

Van der Duim et al. (2015) recommended a regional development strategy focusing on nature-based conservation tourism; this strategy is expected to increase rents from natural capital use without putting at risk the natural capital stock. Our CGE model simulations underpin this viewpoint by indicating the very high return to fish allocated to angling tourism (NAD$715) as compared to subsistence fishing (NAD$10) (Gronau et al., 2017). Compared to the partial product analysis conducted by Tweddle et al. (2015), who also calculated a significantly higher value addition of fish in the angling tourism sector, the economy-wide CGE analysis further derives the coupled opportunity costs of nature conservation. If we model the reduction of total catches to a sustainable level, the resultant impact on selected households varies. The model calculates so-called opportunity costs reflecting households' individual utility loss as a result of the intervention. This information may be used to negotiate compensation payments necessary to make the intervention acceptable to the groups affected by the intervention in different ways. In any case, reducing fishing will make a negative contribution to the already poor food situation and will therefore require accompanying measures.

To compensate for the general nutrient deficit in soils and in food in sub-Saharan Africa, it is strongly recommended to invest in a more diversified agricultural system by increasing the contribution of legumes and trees on farms (Kuyah et al., 2016; Masso et al., 2017; Oborn et al., 2017). The results of our ABM simulations show that investments in agroforestry have a positive income effect in addition to improving soil fertility; the net present value is positive and the cost-benefit ratio is significantly higher than 1.0 compared to continuous maize production without trees. Given the very low incomes of all households, however, start-up aid in the form of microfinance must be provided, since the positive effects of an investment in agroforestry will be felt only after about 11 years (Koch, 2017).

As pointed out by FAO (2014) and Snapp & Pund (2017), a growing number of research papers document the substantial contribution of smallholder agro-ecological production systems to food security and food sovereignty. Although these complex agro-ecosystems have a high level of biodiversity and resilience based on traditional knowledge systems, they have not been sufficiently recognized and developed as a source of inspiration for the design of agricultural systems and for the creation and innovation of scientific knowledge (Altieri et al., 2012; Tittonell, 2014). Research in our study region reveals that traditional knowledge and social capital are slowly disappearing. One cause surely is improper agricultural policy — for instance, subsidizing maize production with the consequence of replacing diverse farming systems by maize monoculture, and moreover creating new financial dependencies along the maize value chain. A landscape approach aims at bringing together competing stakeholders through tools fostering communication and working out a common vision of an area (Perrotton et al., 2017; Salvini et al., 2016). Regarding common rules, our behavioural experiment indicates that communication indeed performs at least as well as strong enforcement (Röttgers, 2016). The development of science-based role plays for negotiations in business and political contexts is one of the services offered by Harvard Law School in the program on negotiation (PON, 2017); correspondingly adapted tools could also be applied in the CBNRM context of developing countries. With the aim of resolving conflicts, environmental games provide an opportunity to discuss the natural, social and political dimensions of political disputes, for example in the field of transboundary water management and climate change adaption (Rumore et al., 2016). There are numerous examples of the willingness of decision makers to participate in such activities, and research on the impact of role-playing on conflict resolution continues. Thus, codesigned framed role plays could also become a standard component of land use management in rural communities to motivate the exchange of knowledge and the adoption of improved farming systems.

Acknowledgements

The research was carried out in the framework of SASSCAL and was sponsored by the German Federal Ministry of Education and Research (BMBF) under promotion number 01LG1201H.

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