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Social-ecological assessment of Lake Manyara basin, Tanzania: a mixed method approach

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Abstract

The social-ecological system of the Lake Manyara basin (Northern Tanzania), a UNESCO Biosphere reserve (BR) suffers from socio-economic and environmental problems due to decreasing water levels, erosion and land and water use conflicts. An integrated assessment of the social-ecological interactions of the area is required to support future sustainable management. Within the Drivers-Pressures-State-Impact-Response (DPSIR) framework an integrated literature review and several methods of knowledge collection were combined to identify future management priorities and challenges. Focus groups with farmers and pastoralists collected a comprehensive set of statements about the situation. The stakeholders confirmed the role played by land use changes as driver and pressure in the landscape for increased erosion rates and siltation of the lake. Moreover, economic and social issues were identified as prominent factors being influenced by, or influencing these processes. These statements match the scientific literature. During participatory mapping exercises different spatial and resource allocation perceptions appeared amongst pastoralists and farmers. This multidisciplinary approach proved to be useful to acquire an integrated and comprehensive understanding of the state, challenges and opportunities of Lake Manyara BR, to feed into a decision support system in service of an integrated management plan. Our assessment suggests that improved water governance in an integrated multi-actor approach (with a focus on distribution, rights, role of the water authorities) should be a priority for future integrated management strategies. Also, awareness raising amongst decision makers, scientists and local communities is needed to demonstrate the advantages of an integrated approach. And finally, visible and fair mechanisms to share conservation revenues should be designed in a way that local benefits can be obtained together with incentive mechanisms for co-management and conservation.

Keywords: social-ecological system, Lake Manyara, knowledge collection, integrated management, conservation, DPSIR

1. Introduction

Lake Manyara (LM) basin (also called 'Manyara' in the text) in the Northern Tanzanian Rift Valley is a biodiversity hotspot. Lake Manyara, a shallow soda lake, is the epicentre of Lake Manyara National Park (LMNP) which has since 1981, been one of the seven Tanzanian UNESCO Man and Biosphere reserves (UNESCO, 2015, Pool-Stanvliet and Clüsener-Godt, 2013). LMNP is an Important Bird Area (IBA) (BirdLife, 2018) and it is part of the famous 'Northern safari circuit' for tourists. Cordeiro (1990) reported e.g. 180 species of butterflies, and Loth and Prins (1986) reported 350 species of birds in LMNP. With the other iconic protected areas in Northern Tanzania, LMNP generates much-needed direct (tourist visits) and indirect (the service sector and trade) tourism revenues (DTIS, 2016). Besides for conservation, the wider LM catchment is also important for regional food security and pastoral- and agricultural livelihoods (Ngana et al., 2003). This contributes to poverty reduction but also drives strong immigration of people seeking new economic opportunities in the region (Njole, 2011). It further exacerbates an already tense demographic situation compared with the limited carrying capacity of the semi-arid ecosystem (Loibooki, 2008). Currently, multiple social and economic drivers, which are rooted in historical disruptions of the social-ecological system (SES), are pushing communities towards the unsustainable use of natural resources (Blake 2018; Wynants et al. 2019). This complex social-ecological system (*sensu* Ostrom, 2009) provides an interesting case of intermingled social-economic and environmental threats and opportunities (Loibooki, 2008, Kideghesho et al., 2015, UNESCO, 2015).

Despite, but also because of these economic and ecological assets, the multiple use and management of ecosystem services is prone to environmental degradation and even to serious conflicts among stakeholders with different priorities. Lake Manyara itself is threatened by (1) episodic droughts and declining water levels due to excessive water capture by agriculture and possibly less rainfall due to climate change and (2) sedimentation because of erosion in the catchment basin (Kiwango, 2009a), which itself is exacerbated by deforestation, overgrazing and violent downpours and floods (Blake et al. 2018). A 30-year (1988-2016) land cover reconstruction by Wynants et al. (2018) found a net conversion of natural or semi-natural land cover towards agricultural uses in the Lake Manyara catchment. The biggest net declining land cover types are 'bushland', 'seasonal grassland' and 'permanent savannah', which were reduced by 8.7, 6.1 and 3.5% respectively. Moreover, the conversion has often occurred in areas that are naturally vulnerable due to topography, soil type and rainfall patterns, thereby seriously increasing runoff and soil erosion risk. While the environmental effects of land cover change are relatively well understood, the social-economic causes and effects are not (Blake et al. 2018). This has not only impacted the foraging of ca 1 million Lesser Flamingos *Phoeniconaias minor* (TANAPA, 2005), which potentially threatens tourism, but also on other aquatic biodiversity, threatening fisheries and the associated value chain extending well beyond the Manyara area (Nonga et al., 2010). Moreover, the flamingos suffer from episodic blooms of toxic cyanobacteria (Lugomela et al., 2006, Nonga et al., 2010).

This study follows the approach of Jahn et al. (2012), who propose to foster co-identification of key management issues and the co-creation of solutions. Acknowledging the plurality of stakeholder perspectives andthe associated importance of inter-stakeholder relationships is key to come up with sustainable management ideas. Indeed stakeholders may have divergent views on who should own and control the use of Lake Manyara's natural resources, on what ecosystem services should be maximized, and on who should make the decisions on how the resources should be managed and used, on who should benefit etc. Inevitably plural subjective viewpoints indicate alternative future management regimes. This study recognizes this diversity of viewpoints, reflecting how different stakeholders see and talk about natural resources management, and contributes to develop proactive and resilient natural resource management approaches (Moore et al., 2009). Views may also diverge on the sustainability of the current management regimes of Lake Manyara from a socio-economic and ecological perspective, reflecting the multiple interpretations of sustainability (Hugé et al., 2016).

Hence it is essential to integrate natural and social science approaches to disentangle the complexity of the Lake Manyara social-ecological system.

The local inhabitants and the local and national authorities are relatively well-aware of the environmental issues at stake (Ngana et al., 2003, Njole, 2011, Vice President's Office, 2012, 2015). However, till 2012 Manyara had no comprehensive integrated management plan, despite several recommendations to carry out studies which might lead to a strategic plan, such as strategic environmental assessments (Mwalyosi, 1991, Melita, 1998, Mwalyosi et al., 1999, Hokkanen, 2002, Ngana et al., 2003, 2004, Sumba et al., 2005, Kiwango, 2009a), or participatory land use planning (Ujamaa Community Resource team, 2010). A General Management Plan was established for LMNP for the period 2014-2024 (UNESCO, 2015), which is mainly a description of existing environmental issues and governance structures with some recommendations. Next to that, other management plans exist for Manyara Ranch and Burunge Wildlife Management Area, which are also part of Lake Manyara BR. A comprehensive implementation of these management plans across the basin is challenging given different views among resource users within the basin.

In the present study we contribute to an improved general understanding of the issues at stake using and integrating stakeholder knowledge and perceptions through an 'ecosystem service lens' and scientific lens through literature (Fisher et al., 2014, Harrison et al., 2014). We structured this analysis within the general framework of Drivers-Pressures-State-Impact-Response (e.g. Maxim et al., 2009) for more clarity and understanding of inter-dependencies. The exercise also allows to identify knowledge gaps and to design future research tracks with short- and long-term management implications in the context of African biosphere reserves. The DPSIR framework provides an opportunity to organize and structure information by linking the human and environmental dimensions of a social-ecological system (Benitez-Capistros et al., 2014; Garia et al., 2015; Tscherning et al., 2012). Next to this information-structuring potential, DPSIR can also be an effective communication tool between scientists, decision-makers and local stakeholders (Svarstad et al., 2008). Adaptations to the original DPSIR-framework were made to conceptualize ecosystem services as a first set of impacts, which form a bridge between ecosystem state and impacts on human well-being (Armsworth et al., 2007, Müller and Brukhard, 2012, Fisher et al., 2014; Fig. 1).

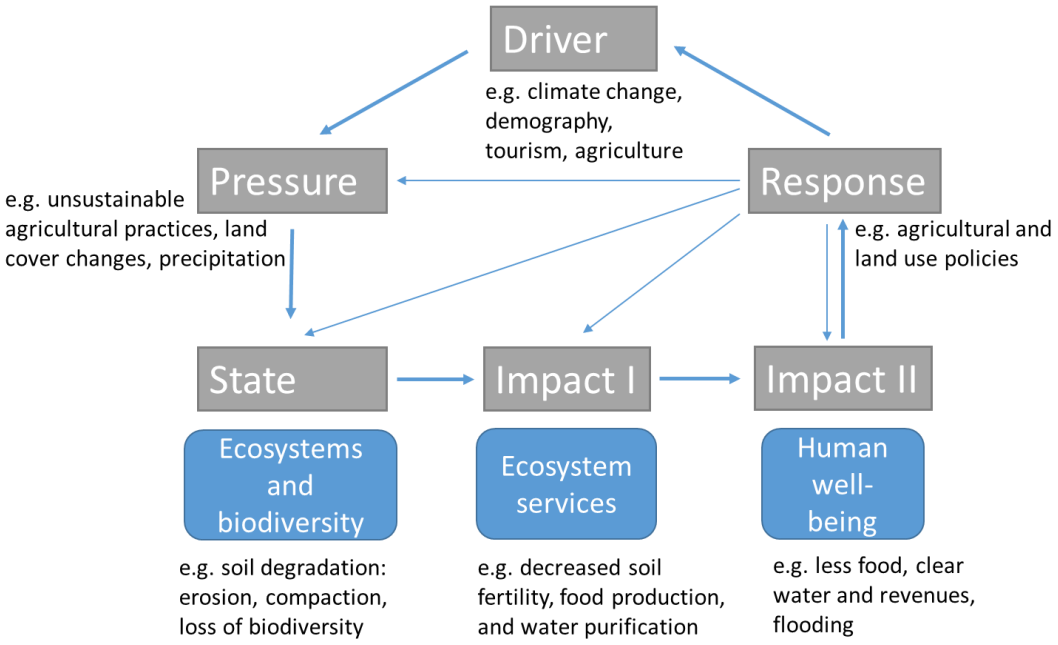

Fig. 1: The adapted Drivers-Pressures-State-Impact-Response framework that includes ecosystem services as a first set of impacts (adapted from Müller and Brukhard, 2012), with examples related to soil erosion issues and 'social impacts' or impacts related to the human well-being.

The present field study includes not only a knowledge scoping exercise (perception study), but also a stakeholder engagement exercise, which is an active social process that can be characterized as participative, iterative and tiered. Hence the outcomes were innovative in many ways: (1) the North-South-South project-based academic cooperation involving not only scientists from several disciplines (biologists (ichthyology, freshwater ecology, botany), bio-engineers (remote sensing, nutrient analysis), geo-morphologists, experts in judgement elicitation techniques) from Tanzania, but also Zimbabwe, South Africa, Belgium and the United Kingdom, and combined with Trias, a Belgian NGO , (2) the participative knowledge collection process itself, with the local stakeholders: increased awareness, knowledge (capacity building) and mutual understanding (conflict mitigation), with potential transformative impact and (3) a better scientific understanding of the environmental issues at stake and the perception about it. This outcome is elaborated in this paper and compared with literature in order to find clues for a decision support system for a more integrated management of the area. Similar to the approach described by Young et al. (2016a), we made an 'in-conflict assessment' to provide a snapshot of the state, drivers and impact of the current situation (UN 2012) based on stakeholder perceptions. We analysed scientific literature, grey literature and gathered qualitative data from two workshops with a total of 40 participants and 13 semi-structured interviews.

Materials and Methods

2.1. Site description: Lake Manyara basin

Lake Manyara has a catchment area of about 18,372 km² with elevations between 938 m and 3633 m above sea level. It is a closed basin with no natural outlet (Wynants et al., 2018). The lake is shallow (Deus et al., 2013), varies in area (max. 480 km²) and sometimes dries up completely. The Western side of the lake is flanked by a steep rift escarpment, to the North are the Ngorongoro highlands, while in the East and Southeast an undulating plain with isolated volcanic mountains gives way to a peneplain. Several springs, streams, wetlands and smaller lakes, both perennial and seasonal, drain into the lake. The shores of the saline lake host at its Northern tip the town of Mto wa Mbu with its irrigation agriculture (estimated inhabitants, 2012 census, ± 12000, ±18000 in 2015 and we suspect higher numbers anno 2019). On its Western side there is a groundwater forest extending between the lake shore and the rift escarpment and covered mostly by the National Park until the Marang' forest. In the rift valley South of the lake vast river floodplains are used for irrigation agriculture. The wetter and productive uplands all over the catchment are mostly used for rain-fed agriculture by various ethnicities depending on historical migration and resettlement patterns. The drier and more unpredictable savannahs are used for livestock grazing by pastoralists (mainly Maasai). Southeast of LM another large and famous national park (Tarangire) is located. Furthermore, all over the catchment there are numerous game reserves, conservation areas, forest reserves, wildlife management areas and numerous villages and touristic infrastructures (roads, lodges and tented camps). Nine major rivers, with highly variable discharge regimes, catchment areas and environmental characteristics, drain into the lake, combined with direct inflow from smaller rivers and springs (Fig. 2).

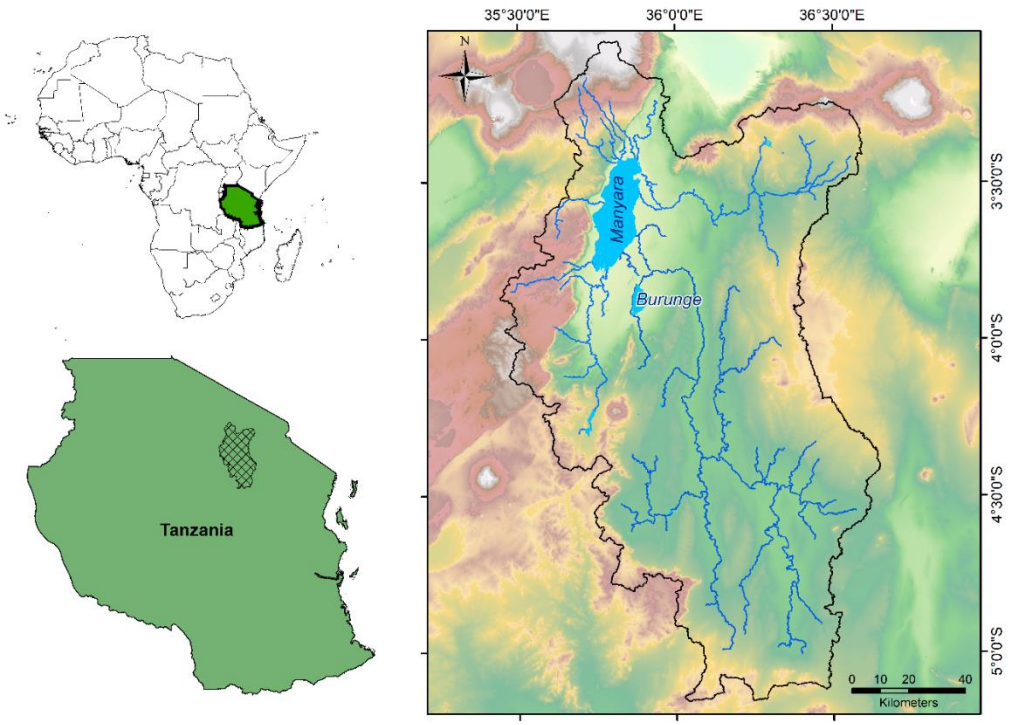

Fig. 2. The Lake Manyara catchment in Tanzania and its hydrological network (adapted from Wynants, 2018)

2.2. Methodology

2.2.1 Overview of the methodological framework

Following Jahn et al. (2012), we use a two-track approach to gather and produce new, integrated and complementary knowledge, building on (1) scientific and grey literature and (2) societal inputs– effectively realizing a multi- and transdisciplinary social-ecological assessment of the Manyara basin. This mixed method approach (Table 1) identifies and describes social-ecological challenges (e.g. Kohtala, 2015, Hugé et al., 2016).

Table 1. Overview of methods used

Method	**Objective**	**Output**	**Multi- and transdisciplinary aspects**	**Methodological backing**
Integrated Literature Review	To collect and integrate existing scientific knowledge about Lake Manyara by focusing on representative peer-reviewed and grey literature sources	List of drivers of environmental conflict and list of responses per thematic clusters	The literature consulted spans a broad range of topics, from physical, biological to social aspects. It is a multi-disciplinary overview.	Kohtala (2015)

Focus groups	To collect stakeholders' perceptions on ecosystem services & their dynamics in participative workshop settings	Participatory maps, problem tree & priority ecosystem services & their dynamics	The stakeholders consulted ranged from farmers, pastoralists to authorities, NGOs and academics. The discussion here is transdisciplinary, since the different stakeholders learned from each other and produced new knowledge.	Nyumba et al. (2018) Raum (2018), Peh et al., 2013
Key informant interviews	To refine the understanding of stakeholder perception regarding ecosystem services and environmental challenges by means of individual interviews	Identification of environmental drivers, pressures, state, impact, response (DPSIR)	The interviewer conducted a survey amongst key informants from NGOs, conservation and development agencies, and the private sector. It complements the other methods and stakeholders and considered multidisciplinary, as the questions refer to a wide range of disciplines.	Bogner et al. (2009) Young et al. (2018)

2.2.2. Integrated Literature Review

The literature was analysed using qualitative content analysis (Fig.3), inspired by the stepwise approach used by Rose *et al.,* (2016):

1- Initial codes (COD1) were extracted from the literature Similar COD1 were listed within two clusters of statements concerning: (1) drivers of environmental problems or conflict in Manyara, corresponding to the DPSI of DPSIR framework and (2) recommendations and solutions, corresponding to the R of the DPSIR framework. (annex 1 in Janssens de Bisthoven, 2020)).

2- Then, we aggregated the COD1 to a limited number of synthesizing statements (merged codes COD2), in order to reduce the complexity of information to the most essential.

3- Both 'problem-focused statements' and 'solutions-focused statements' were assigned to 10 broad thematic clusters (COD3). They were defined a first time, then re-ordered several times and by several co-authors to avoid redundancies and seek for a more optimal clustering.

4-Finally, the information collected by way of this integrated literature review was benchmarked against the focus groups' findings (Fig. 5).

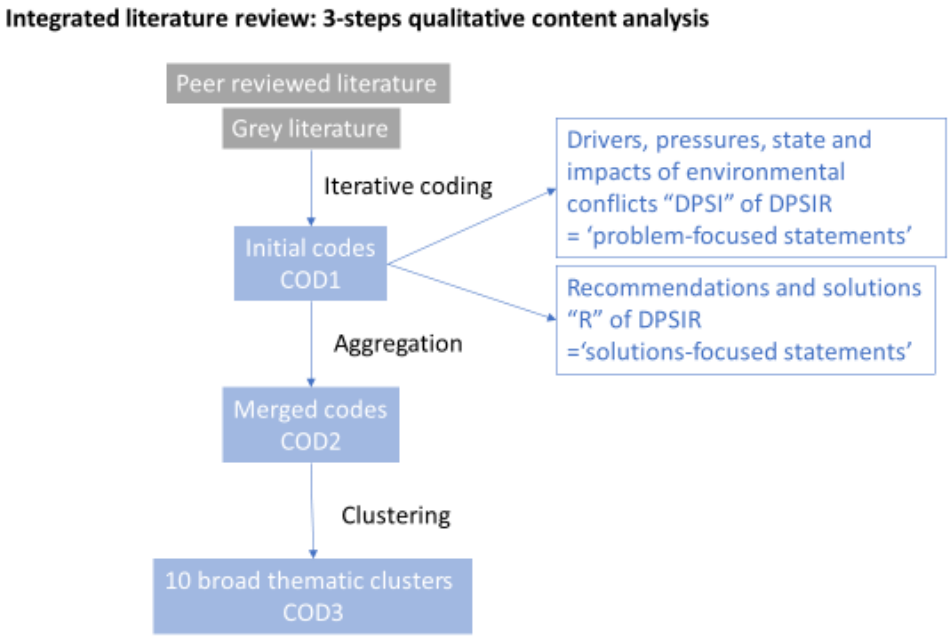

Fig. 3. Flow chart representing the three-steps coding in the qualitative content analysis applied for the integrated literature review. The literature was screened for a number of initial statements encoded as COD1 (annex 1 in Janssens de Bisthoven, 2020), which were assigned as either 'problem-focused' or 'solution-focused', and then merged into a more restricted number of synthetizing statements (merged codes COD2), which were assigned to 10 broad thematic clusters (COD3).

2.2.3. Focus groups

Two participative workshops were held in resp. December 2015 and December 2016, and both followed a tiered approach, inspired by a method for the rapid assessment of ecosystem services, TESSA (Peh et al., 2013). Focus groups were conducted drawing from the approaches reviewed in Reed (2008), Reed et al. (2009), Raum (2018) and Nyumba et al. (2018) and were conducted in English with simultaneous translation in Kiswahili. The workshops combined the strength of individual and collective reflection, as in the nominal group technique (NGT) described by Hugé & Mukherjee (2018).

In **Focus Group 1** (2015, n=17 participants), a participatory mapping exercise was done, inspired by the work of Corbett and Rambaldi (2009): stakeholders were divided into 4 groups of 3-6 persons: officials (representatives of the authorities), scientists, pastoralists and farmers (or their representatives). Without explaining the expected outcome of the exercise, each group was asked to draw a map of the Lake Manyara basin on large paper sheets without external support or pre-existing maps. The only guideline provided was to draw a map indicating water bodies, land use (forest, grazing areas, borders, tenures, movements (arrows), areas suitable for agriculture, 'shambas' (little fields), crops, settlements, villages, roads), harvest and resources as well as other processes and activities (areas of conflicts, erosion, spiritual areas, tourism). The terminology used was derived from commonly used practices, *i.e.* academic jargon such as 'ecosystem services' was avoided. The maps are presented in annex 2 (Janssens de Bisthoven, 2020). Once the mapping done, the group was asked

to construct collectively a problem tree, with as central problem the drying of the lake, the possible reasons and the consequences.

In **Focus Group 2** (2016, n=18 participants), priority ecosystem service flows, deliverers and beneficiaries were identified. The importance of each ecosystem service was identified using an individual questionnaire adapted from Palomo *et al.* (2013) (see annex 3, Janssens de Bisthoven, 2020)). The participants were given a list of the 26 most important services identified by previous studies in the area. The list provided an example and definition for each ecosystem service. The participants were then asked to identify the trends shown by these ecosystem services in the past decade, and to score these from 1 (not important) to 5 (very important)(Likert scale). The participants also selected five priority ecosystem services. The dynamics of the four ecosystem services that were most frequently cited as priority were then developed on paper sheets with one group per priority ecosystem service according to the scheme in Fig. 4, to obtain information about (1) the main pressures affecting the service, (2) the processes (positively or negatively) affecting the delivery of the services, and (3) the main providers and beneficiaries of the services.

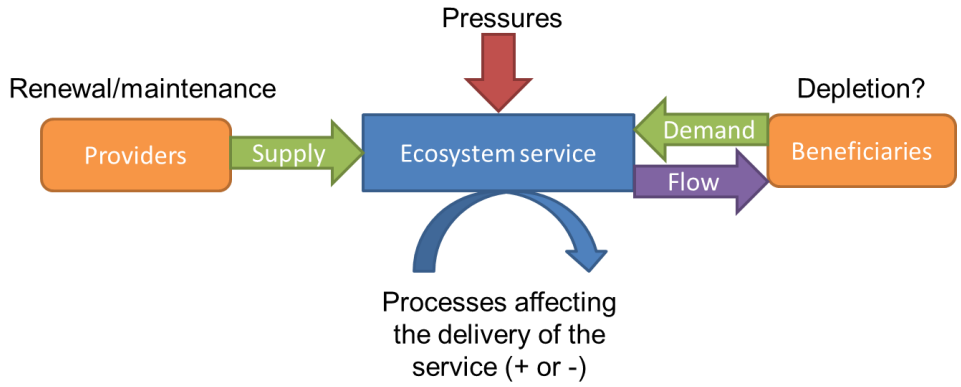

Fig. 4: Scheme used as a reference for each group of participants to document the dynamics of the four ecosystem services that were most cited as priority.

2.2.4. Key informant interviews

In June 2017, thirteen individual semi-structured interviews were conducted to refine and elaborate the perception of stakeholders towards the benefits generated by ecosystem services of Lake Manyara and to gain additional information on environmental challenges and management options (following the guidelines proposed by Young et al., 2018). The objective was to collect this information from stakeholders that were not present during the focus groups. Key informants were defined as having privileged access to information on the Lake Manyara basin and a high level of knowledge that is otherwise difficult to access in a direct science-stakeholder dialogue (cf. Burgman et al, 2005). They were representatives from NGOs, development and conservation agencies, and the private sector (tourism). We applied systematizing expert interviews (Bogner et al., 2009) which focus on the exclusivity of expert knowledge and require interviews with multiple experts to be able to compare and aggregate data to gain process knowledge.
The answers were analysed using qualitative content analysis based on the stepwise approach used by Rose et al. (2016):

1- Each interview was coded manually to look for key themes: initial codes were manually extracted from the answers.
2- Subsequently, similar initial codes were joined to form merged codes. The number of persons having cited the codes during the interviews was recorded.

3- We ended by classifying the resulting merged codes into a generic DPSIR framework. The "state (S of DPSIR)" and "environmental impacts (I of DPSIR)" categories were merged as most statements were difficult to classify in those two categories. A "social impacts" category was added to better reflect the impacts on human well-being, as in the adapted framework presented in Fig. 1.

2.2.5. Benchmarking the results obtained through the different methods

Merged codes from the integrated literature review were systematically benchmarked against the ones resulting from the key-informants interviews, to check for overlaps and differences. Initial codes from the interviews were also considered when interviews merged codes were too general compared to the ones from the literature review. Results from the focus groups contribute to the discussion about these comparisons.

3. Results

3.1. Integrated literature review: an overall picture of environmental change, conflicts and solutions in the Lake Manyara basin

We extracted 97 problem statements and 101 solution statements (initial codes COD1, see annex 1 in Janssens de Bisthoven, 2020) in the selected literature. These were aggregated in merged codes COD2 and assigned to 10 broad thematic clusters (coded as COD3). The COD3 clusters were defined as representing the key elements of resilience in a social-ecological system, being ecological, economical and sociological components (Holling, 2001). They were 'a posteriori' linked to the Sustainable Development Goals (SDGs) and the Aichi targets of the 2020 Strategic Plan for Biodiversity of the Convention on Biological Diversity in order to define the policy context where these data can be situated (Table 2). Finally, each COD3 was linked whenever possible to ecosystem services, in order to make the link with the benefits provided by the ecosystem and to link with our workshops on perceptions regarding ecosystem services.

Table 2. Synthesis of the integrated literature review, identifying drivers and pressures of environmental problems, as well as their impacts, threats and conflicts in Lake Manyara. Synthesis of initial codes COD1 (annex 1) is provided in COD2 columns. The broad thematic clusters (COD3) are linked to the Sustainable Development Goals (SDG), the Aichi targets of the 2020 CBD strategy, the elements contributing to ecosystem resilience space and the related ecosystem services (ES).

Broad thematic clusters (COD3). All 10 clusters are assigned to DPSIR.	**'Problem-focused Statements': drivers, pressure, State and causes of environmental problems, threats and conflicts in Manyara.**	**'Solutions-focused statements': Response, solutions. Most are related to 'Response' of DPSIR.**	**Link to policy, resilience space and ecosystem services**			
COD3	**Synthesizing statements (merged codes COD2)**	**Synthesizing statements (merged codes COD2)**	SDG	Aichi	Resilience space	Ecosystem services (ES)
1-DEMOGRAPHY-POVERTY-LIVELIHOOD (Drivers)	1. Human and livestock population growth; 2. Pervasive poverty; 3. Misguided development (e.g. villagization, alienation of grazing lands);	1. Alternative agro-based income- and protein-generating activities; 2. Reconcile conservation & development with communities;	1	2	Sociology	all
2-KNOWLEDGE-INFORMATION-EDUCATION-AWARENESS (Drivers)	4. Lack of knowledge regarding sustainable natural resources management; 5. Poor education and coordination; 6. Ignorance and lack of interconnection between different natural resources management rules and sectors; 7. Lack of data; 8. Ignoring traditions, customs and norms;	3. Capacity-building and awareness-raising regarding conservation; 4. Cooperation between involved actors 5. Building on past successes; 6. Capacity-building for better irrigation and agricultural practices; 7. Community monitoring; 8. Awareness raising regarding corruption; 9. Information-sharing schemes;	4	1	Sociology	No ES as such, but awareness, education and information are the prerequisites to facilitate access and sustainable use of ES
3-CONFLICTS – DEGRADATION – LAND USE (Driver-State-Pressure-Impacts)	8. Land use conflicts ; 9. Human-wildlife conflicts; 10. Water conflicts; 11. Enforcement & governance issues; 12. Conflicting policies and sectors about land use and conservation; 13. Conflicting interests and use of natural resources;	10. Land use planning; 11. Better agricultural practices; 12. Collective law enforcement; 13. Report on corruption; 14. Delimiting protected areas in a clearly visible way;	10, 15, 16	5, 6, 7, 12-15	Sociology and Ecology	all

4-POLLUTION (Pressure, Impacts)	14. Agricultural pollution; 15. Household water pollution; 16. Mining pollution;	15. Monitoring of water quality & quantity; 16. Capacity building regarding agrochemicals use; 17. Strict norms and licences for mining ;	6	8	Ecology	Water provisioning and purification
5-PLANNING-COMMUNITY (State, Impact)	17. Lack of participation, dominance of top-down; 18. Cultural insensitivity; 19. Lack of transparency about control over key resources; 20. Lack of provision of services; 21. Discrepancy between policies and the realities in the field; 22. Lack of inter-actor and inter-sector coordination regarding natural resources management; 23. Corruption; 24. Poor water governance; 25. Lack of expertise and facilitation;	18. Community-based natural resources management (CBNRM), Collaborative natural resource governance, community patrolling & enforcement; 19. Foster self-reliance when dealing with conservation conflicts, fee charging systems; 20. Capacity-building; 21. Integrated Land use planning (conservation, agriculture); 22. Improved coordination and co-design and -management, compensation and awarding schemes; 23. Re-think the water governance; 24. Re-think farming practices; 25. Strategy of Tanapa should be developed/adapted for Manyara; 26. Implementation and enforcement of existing plans, strategies, policies, harmonisation; 27. Strategic Environmental assessments; 28. Implement monitoring and evaluation;	1, 16, 17		Sociology	No ES as such, but good planning and community ownership facilitate the access to ES in a direct or a monetary way through redistribution or e.g. Payment for Ecosystem Services schemes.
6-LIVESTOCK (pressure)	26. Overstocking; 27. Livestock grazes everywhere;	29. Decrease number of livestock (including promotion of zero grazing);	2	7	Economy	Food for cattle (sufficient grassland, good grass) and water provisioning
7-WATER PLANNING-DATA (Drivers, Pressure, State, Impact)	28. Lack of water data (quality, quantity, needs, distribution); 29. Climate change, floods; 30. Water borne diseases; 31. New water users; 32. Division of tasks & responsibilities; 33. Sedimentation;	30. Improved irrigation techniques; 31. Monitoring & surveying of water use and associated land use change; 32. Improve and implement user rights;	6		Ecology	Water, erosion control (trees, forests)
8-AGRICULTURAL PRACTICES (Pressure)	34. Land tenure and use conflicts; 35. Lack of long-term implementation & sustainability of projects;	33. Choice of adapted crops; 34. Use cheap soil-conservation techniques; 35. Increase trees in the landscape;	2	7	Economy	Water and soil fertility

	36. Poor agricultural practices leading to salinization, soil degradation, fire; 37. Poor land use practices deforestation, lack of implementation of tree planting schemes,) leading to soil erosion; 38. Strong cattle-based cultural identity, weak governance structures, and a lack of resources and motivation for community action to protect shared land;	36. Alternative income-generating activities (e.g. bee-keeping);				
9-TOURISM	39. Intensification of tourism; 40. Decrease of wildlife;	37. Benefit-sharing mechanisms to ensure tourism revenue reaches as many as possible, eventual link to agriculture; 38. Improve tourist industry (social standards);	8	14	Economy	Recreation (wildlife, biodiversity), esthetical and scientific value
10-LEGAL (Drivers)	41. Inadequate laws and law and bylaws enforcement and awareness; 42. Historic water rights not adapted anymore;	39. Law enforcement 40. Land use plans 41. Review of existing water rights & laws	16		Sociology	No ES as such, but law, governance and policies will govern access and sustainable use of the ES
Total **COD3: 10**	**Total COD2 (problems): 43**	**Total COD2 (solutions): 41**				

Literature: Problems-focused statements: Kiwango (2009a,b), Ngana et al. (2003), Loibooki (2008), Njole (2011), Rohde and Hilhorst (2001), Kihwele and Moronda (2004), Mwalyosi (1991), Ngana et al. (2004), Nonga et al. (2010), Nonga et al. (2011); Blake et al.(2018), Babati et al. (2005) ; Bluwstein et al. (2016); UNESCO (2015); Sulle et al. (2011); Kideghesho et al.(2013); Hongoa (2014); African Wildlife Foundation (2003); Moyoa et al. (2016), Wynants et al. (2018); Wynants et al. (2019).

Solutions-focused statements: Ngana et al. (2003), Njole (2011), Sumba et al. (2005), Kiwango (2009b), Mwalyosi et al. (1999), Kihwele and Moronda (2004), Rohde and Hilhorst (2001), Sumba et al. (2005), Kiwango (2009a), Prins (1987), Kiwango (2013), Nonga et al. (2010), Nonga et al. (2011); Blake et al. (2018); Babati et al. (2005) ; Kiffner et al. (2015); Funk (2015); Bluwstein et al. (2016); Mwalyosi (1991); UNESCO (2015); Bencina et al. (2016); Sumba et al.(2005).

Independently we achieved an almost equal number of summarizing statements concerning respectively problems and solutions (each about 45 COD2), which corresponds to about half of the original extracted statements (COD1) . We realized that the relation to ecosystem services is not always easy to define or "one to one", since ES do not include the governance and community aspects, nor the ecosystem disservices, as discussed by Lele et al. (2013).

3.2 Results of the focus groups

3.2.1. Participatory mapping: different perceptions of the Manyara socio-ecological system

The participatory drawn maps can be consulted in annex 2 (Janssens de Bisthoven, 2020). Only the pastoralists displayed their map through a horizontal/landscape orientation. The farmers showed roads that are important points of reference in terms of commercial exchanges. The authorities and scientists delivered maps that gave details one can gain through reading about the area; they “framed” the area within the borders of the catchment area. The plenary reporting of the maps by the informant groups revealed top two priorities as follows: officials mentioned: (1) catchment and (2) the different lakes. The scientists mentioned: (1) the orientation of the map, and (2) settlements. The farmers mentioned: (1) the road from Karatu to Arusha, and (2) the Rift Valley. The pastoralists mentioned: (1) the Eastern shore drawn horizontally, and (2) Lake Manyara. Collecting this information helps to understand environmental issues regarding Lake Manyara in a holistic way, by giving the opportunity and the time to the focus group participants to deliver their story, seen as ‘fragments of information’ (scientific, local, traditional).

3.2.2 Identification of drivers, pressures, impact and prioritization of ecosystem services and flows

A representative mix of stakeholders delivered during a participative problem tree analysis their individual ideas on drivers, causes, threats and effects of the drying up of the lake, identified as the focus of concern during the first workshop in 2015. About 12 ‘causes’ were identified, influencing 8 issues, the so-called ‘effects'.

The ‘**causes’ (drivers, pressures)** were identified as: (1) demographical factors, (2) siltation, (3) erosion, (4) river dry-up, (5) deforestation, (6) destruction of water sources, (7) human activities near the lake, (8) water capture before the water reaches the lake, (9) heavy rainfall causing erosion, (10) evaporation, (11) trampling and (12) grazing. The 'causes' (1), (2), (3), (5), (7), (8), (9), (11) and (12) are all found in the literature review (Table 2). However, the stakeholders in the workshops came up with new information such as (6) and (11).

The ‘**effects’** (**pressures, impact**) were identified as: (1) loss of biodiversity, (2) dead flamingos, (3) dead species which depend on lake, (4) increased water conflicts, (5) reduced revenue from tourism, less tourists, decreased income for the National Park, (6) need for more migration of cattle, (7) fisheries collapse, (8) system changes when lake disappears, affecting livelihood and food insecurity. Here also, most information about possible 'effects' can be found in the literature (Table 2). However, we found that the workshop participants were reflecting a step ahead of the literature by thinking or worrying about future scenarios in the event of a complete drying up of the lake (effect 8) and the need for more migration of cattle herds (effect 6) and fisheries collapse (effect 7).

Some statements were surprising: e.g. (1) the pastoralists did not perceive the drying of the lake as a huge problem since they do not make direct use of it (saline water cannot be drunk), while other stakeholders referred to the negative impact that the drying of the lake will have, i.e. loss of tourism due to loss of wildlife. (2) Moreover, food security was for some participants not really an issue as

most farmers harvest more than what is needed. (3) Algal blooms were mentioned by scientists and authorities, as they perceive or predict serious consequences on the ecological health of the lake, like mass mortality of flamingos (see e.g. Lugomela et al., 2006).

During the 2016 focus groups, participants were also asked to respond to questionnaires (annex 3, Janssens de Bisthoven, 2020)) that enabled to assign a relative importance to the ecosystem services in the area and to their trends, meaning increase or decrease during previous years (Table 3).

In order of importance, the four services with the highest average scores were (1) water provision, (2) food provided by agriculture, (3) erosion control and (4) food provided by cattle. The ecosystem services most often selected as priority were (1) water provision, (2) food provided by agriculture, (3) erosion control and (4) climate regulation. Services identified by most participants as "diminishing" were (1) water provision, (2) soil fertility, (3) biological control, (4) traditional knowledge, (5) disaster mitigation, (6) biomass for energy, (7) spiritual value, (8) food provided by fishing and (9) food provided by hunting.

Table 3: Focus group results (1): Summary of ecosystem services and related issues: trends and prioritization perceived by the focus group participants (n=18). The relative importance of the service (mean score 1-5), the trend (based on the majority of participants' views) and the number of times the service was selected as priority are shown.

Ecosystem service	**Mean score**	**Trend**	**Times selected as priority ES**
Water provision	4.9	↘	10
Food provided by agriculture	4.5	↗	8
Erosion control	4.3	→	3
Food provided by cattle	4.1	↗	3
Soil fertility	4.0	↗	2
Environmental education	4.0	↘	3
Climate regulation	3.9	↗	4
Scientific knowledge	3.8	↗	3
Aesthetic values	3.8	→	2
Biological control	3.7	↘	3
Disaster mitigation	3.6	↘	2
Traditional knowledge	3.6	↘	1
Water regulation	3.5	↘→	1
Existence value and species conservation	3.5	→	1
Medication and therapeutic compounds	3.5	→	1
Air purification	3.4	→	0
Raw material of biological origin	3.2	→	2
Habitat for species	3.2	→	1
Wildlife tourism	3.2	↗	2
Water depuration	3.0	→	1
Pollination	2.9	↘→	0
Biomass for energy	2.7	↘	1
Spiritual value	2.6	↗	1
Beekeeping	2.5	↘	0
Food provided by fishing	1.5	↘	0
Food provided by hunting	1.3	↘	0

The four ecosystem services most often selected as priority were then further documented by groups on large paper sheets, using as basis a scheme illustrating the dynamics of ecosystem services (Fig. 4). Groups were assigned to each service, based on the expertise and profile of the participants: farmers documented 'food from agriculture', while pastoralists documented 'water'. For practical reasons related to the profile and number of participants, climate change and erosion control were addressed together, by authorities and scientists (Table 4).

Table 4: Focus group results (2): Summary of participatory judgement elicitation on the dynamics of the four ecosystem services that were most cited as priority.

	DPSIR			
Ecosystem service addressed	**Pressures**	**Processes affecting the stocks delivery of the service (+ or -) (Response and drivers/pressures)**	**Providers (renewal/maintenance)**	**Beneficiaries (Depletion)**
Climate change and erosion control (by Authorities and scientists)	• Global change • Overgrazing • Deforestation • Poor agricultural practices • Natural processes e.g. landslides • Urbanization and population growth	• Good agricultural practices (crop rotation, terracing, nutrient appl.) • Livestock stocking density • Land use plan • Grazing calendar • Sustainable forestry	• Central government (MOWI, MNST, DC's) • Internal Drainage Basin • TANAPA • NCAA • Forestry Reserve • WMA • Local community • Local + international NGOs (MVIWATA, UCRT, TRIAS*, Manyara Ranch)	• Farmers • Pastoralists • Wildlife • Tourism industry • Government • The community • Fishermen • Business (hotels, lodge, small businesses)
Food from agriculture (by farmers)	• Transportation • Conflicts between farmers and pastoralists • Capital • Education and technology • Pests and disease • Fertility • Market and Price	• Drought • Flood • Wildlife • Geographical position-remoteness • Politics (multiparty conflict)	• Farmers • Government • Businessman/trader • Donors/NGOs	• Farmers • Pastoralists • Civil workers • Students • Military • Prisoners • Fisheries • Tourists
Water (by pastoralists)	• Drought (prolonged) • Unexpected heavy rain • Strong wind • Cutting down trees • Population increase (humans and cattle) • Soil erosion	• Planting trees • Awareness raising • Land use plans and management	• Forest escarpment • Springs • Dams • Boreholes • Mountains • Lakes • Rivers • Canal irrigation (note that the list refers to natural features as well, because 'providers' were understood in this broad sense)	• Humans (domestic use and construction) • Vegetation • Livestock • Wildlife animals • Aquatic animals Benefits received: • For construction: houses, roads • For domestic use • For agricultural use • For tourism activities • For fishing activities

***** MVIWATA farmers' group: The main purpose of the network is to improve communication amongst farmers 'groups in order to enhance the participation of small-scale farmers in planning, implementation/supervision of social, economic and understanding of political processes/ UCRT: Ujamaa Community Resource Team, UCRT works to empower marginalised people in the rangelands of northern Tanzania to secure rights to their natural resources and land/ TRIAS: Belgian NGO based in Arusha, specialised in entrepreneurship, rural communities and livelihoods.

3.2.3. Results of the Key Informant Interviews

The DPSIR framework was used to organize the merged codes emerging from the qualitative analysis of the key informant interviews. Initial codes leading to the merged codes are listed in Annex 5 (Janssens de Bisthoven, 2020). The obtained Responses (green boxes) were linked to the corresponding DPSI categories (blue boxes) through green double arrows (Fig. 5). Some statements

were cited by more than half of the respondents, such as population increase (driver), unsustainable agricultural practices (pressure), the loss of connectivity and decrease in wildlife migrations (environmental state and impact) and land use conflicts (social impacts) (see underlined statements in Fig. 5). Most cited responses ('R') referred to environmental education, improved agricultural practices and management options to stop floods and erosion, involving communities (and their leaders) in natural resources management and tourism activities, securing land for pasture and wildlife migrations through land use planning, by-laws and Certificates of Customary Right of Occupancy (CCROs), a tool for strengthening community land rights and securing communal lands.

3.3. Benchmarking the results obtained through the different methods

Each synthetizing statement (merged code) originating from the literature review (table 2) was compared with the merged codes coming from the key informants interviews to check for (dis)similarities. Full results can be consulted in annexes 5 and 6 (Janssens de Bisthoven, 2020).

Regarding the 'Problem-focused Statements', only 9 from 42 literature statements (21.4%) do not appear in the interviews results. These are: 3. Misguided development; 7. Lack of data; 10. Water conflicts; 16. Mining pollution; 19. Lack of transparency about control over key resources; 20. Lack of provision of services ; 25. Lack of expertise and facilitation; 31. New water users; 32. Division of tasks & responsibilities.

Regarding the 'Solutions-focused statements', 17 from 41 literature statements (41.5%) are not mentioned in the interviews results: 5. Building on past successes ; 8. Awareness raising regarding corruption; 9. Information-sharing schemes; 12.Collective law enforcement; 13.Report on corruption; 14.Delimiting protected areas in a clearly visible way; 15.Monitoring of water quality & quantity 17.Strict norms and licences for mining ; 19.Foster self-reliance when dealing with conservation conflicts, fee charging systems; 23.Re-think the water governance; 27.Strategic Environmental assessments; 28.Implement monitoring and evaluation; 30.Improved irrigation techniques; 31.Monitoring & surveying of water use and associated land use change; 32.Improve and implement user rights; 39.Law enforcement, 41.Review of existing water rights & laws.

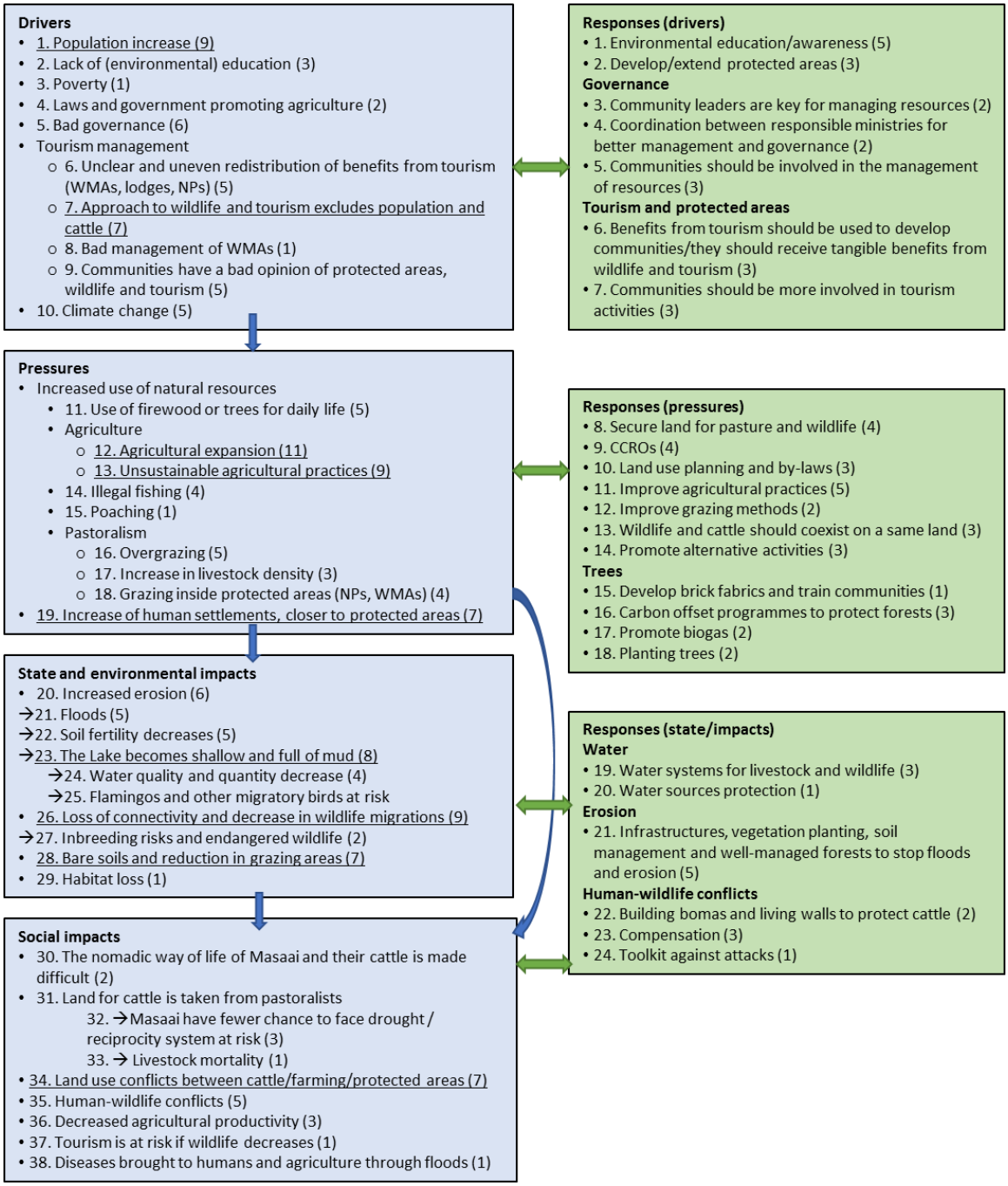

Fig. 5: Merged codes from the key informants interviews responses within the DPSIR framework. Numbers represent occurrences of responses. Codes that are underlined are cited by more than half of the interviewees. Arrows ("→" in the text, and blue arrows between boxes) refer to a causality relationship. Green double arrows link responses ('R') to a corresponding 'DPSI' category.

4. Discussion

4.1. Assessing a rapidly changing social-ecological system – Lake Manyara as an exemplary case?

The area is a diverse and complex social-ecological (Rohde & Hilhorst, 2001) system that is undergoing rapid change. The mixed methods approach we used in this study allowed us to gather views from a range of sources and stakeholders of the Lake Manyara basin. However, we faced the challenges of

information integration and synthesis. The literature suggests dramatic shifts in land use which drives soil erosion, and a multitude of effects on the ecology and the livelihoods (Table 2). This information is confirmed by the elicitation exercises. Participatory mapping allowed to discern rapidly and 'live' the different interests or focus of the stakeholders for distinct features in the landscape. But it also allowed all stakeholders to observe and integrate the different focus of the other groups. We are aware that such small-scale exercise is a 'snapshot' and might not trigger any sustainable or lasting consequences for conflict resolution in the area. However, it underlines, as suggested by Jahn et al. (2012), the potential of this type of science-stakeholder dialogue to deliver through narratives (1) interesting socio-economic and ecological information (and wishes!) to the authorities and scientists who are trying to understand the area and its management options and (2) material for formulating new scientific questions and hypotheses to identify further research. It however also highlights the difficulty of assigning information about the social-ecological system to the DPSIR framework, since many statements can be assigned to several of these functional categories. The use of ecosystem services as a 'common language' proved its usefulness to collect stakeholders' perceptions about benefits in a structured fashion, but on the other hand also pinpointed some limitations, as explained in Lele et al. (2013): the ES approach omits to mention the ecosystem dis-services, trade-offs, the abiotic nature of ecosystems (e.g. mining) and the governance aspects. This is illustrated in Table 2, where we had difficulties in filling the ES column when it comes to sociological (governance-education-planning…) aspects, one of the key resilience elements proposed by Holling (2001).

Focus groups are helpful to redefine new scientific questions, starting from real concerns by the stakeholders. For instance, one small 'fragment of information' during a focus group was e.g. the link between outbreaks of anthrax in cattle and the dynamics of vegetation cover, a topic which would warrant further research either from a One Health perspective (Bengis & Frean, 2014, Antoine-Moussiaux et al., 2019) or from a vegetation dynamics perspective (Prins and van Der Jeugd, 1993).

From the ensuing discussions, questions were asked about the way people deal with conflicts, which is a way to elicit solutions. Pastoralists know the problems, but often lack the means to do anything about it because of multiple other socio-economic factors, such as a lack of local enforcement for rotational grazing. They report that the situation evolves: campsites are now fenced, hence cattle grazing and campsites are less in conflict. Further, the narrative of pastoralists about grazing and erosion includes the statement that alternating grazing areas avoids erosion, or that they wish some areas could be restored by seeding, hence confirming a firm knowledge and/or strong beliefs about best land use practices. As stated by Stepanova et al. (2019), conflict resolution is understood as a dynamic iterative process where different stakeholders (including mediators) initiate attempts to solve the conflict formally and informally in search of "better" management solutions. In this process, stakeholders co-produce, test, use and integrate different knowledge types (Blackmore 2007; Collins et al. 2007. Drivers identified by key informant interviews included tourism-related statements such as 'unclear and uneven redistribution of benefits from tourism, 'Loss of connectivity and decrease in wildlife migrations',_'approach to wildlife and tourism excludes population and cattle', 'bad management of Wildlife Management Areas (WMAs)', 'communities have a bad opinion of protected areas, wildlife and tourism'. Such statements were not expressed as frequently through the other methodological approaches (literature, focus groups), although global governance issues (not directly regarding tourism) were covered by the "Planning-community" cluster in the literature review. The delicate nature of such statements might explain whether they are expressed or not. Tensions may result in worsened people's attitudes towards conservation and can lead to more unsustainable use of natural resources, due to frustrations, decrease in livelihoods and disrespect of environmental rules and laws (e.g. poaching, wood collection, grazing in protected areas or WMAs…) . Interviewees to whom we presented key results of the focus groups were very surprised that tourism was not selected in the priority ES, given the high number of tourists attracted by the National Park and the benefits it generates (11.2% of total visitors to Protected areas in Tanzania in 2014, DTIS, 2016). Environmental conflicts are frequent in other African lakes, such as Lake Victoria (e.g. Odada et al., 2004) or Lake Chad (e.g. Okpara et al., 2015). These studies also explain the many socio-economic aspects

interacting with environmental change. Conflict is a probable outcome only in locations that are already challenged by a multitude of other context-specific factors besides resource scarcity (Okpara et al., 2015). Furthermore, Colding and Barthel (2019) made a useful overview of how authors use the concept of social-ecological system in relation to research that deals with social and ecological linkages.

4.2. Synthesizing and communicating complex social-ecological information about Lake Manyara: lessons learned

While the use of a **mixed methods approach** generated new knowledge and confronted different sources of knowledge with each other, the other main challenge remains how to convey a clear **message to decision-makers** at different levels of decision-making. Sub-dividing a complex social-ecological system (SES) into measurable parameters (as proposed by Ostrom, 2009) is useful but requires a lot of data. Providing a 'threat assessment framework for ecosystem services' (as suggested by Maron et al., 2017) presents clear communication advantages but has a relatively high level of abstraction. Striking a balance between comprehensive data collection and integration, and clearly prioritized management options is a challenge. Nonga et al. (2010) listed from a survey that farming, domestic use, wildlife, livestock use, and fishing were all perceived as very affected by water shortage in the Manyara basin. The respondents cited increased human activities, decreased rainfall and sedimentation as the main reasons. Further, as management options or solutions, clearly, environmental conservation activities and creation of associated bylaws were the most prioritized. On the socio-economic side, the work effectuated by NGOs (both international and local) is crucial to understand the actual state, but also the development trends and perceptions of the local communities. Here the Belgian NGO, Trias, co-author of this paper, realised large scale surveys together with Tanzanian NGOs and concluded that the perception towards wildlife and conservation is rather positive amongst people in surrounding villages and settlements but that few are aware of existing management plans. Further, there is some development towards increased dairy production and higher income amongst the farmer communities, despite the environmental threats identified (Trias, 2016). Apart from a growth of the livestock sector, there is also a noticeable diversification of the economy, with income from business, horticulture and other income growing fast (e.g. salaried work). Nevertheless, 'other income' is still a minor contributor to total GDP, indicating that formal employment is still very rare. So, the social-ecological message about the Manyara basin is mixed, as we detect both environmental threats and both positive or negative socio-economic developments.

4.3. Plural perspectives on governance and conservation: whose lake are we talking about?

Nelson (2015) remarked that "current Tanzanian policies discourage a rational use of pastoralism and conservation", hence pinpointing to the problem of adequate governance linked to conservation and development. Following the framework proposed by Mace (2014), we situate the multiple framing of conservation in the Manyara basin between 'nature for people' (ecosystems providing sustainable benefits for people) and 'people and nature' (dynamic two-way relationships between people and nature). This however, as pointed out by Mace (2014), entails the risk that the conservation deliverables are difficult to achieve, given the complex social-ecological challenges, as observed in other African lakes (e.g. Odada et al., 2004, Okpara et al., 2015).

Our study clearly shows the high focus on water, both in the literature and in the perceptions of the stakeholders. The National Water Policy (Ministry of water and livestock development,2002), followed by the Water Resources Management Act (WRMA) (2009), have both advocated decentralized water governance and the principles of integrated water resources management (IWRM). Although this policy environment is favourable, these approaches experience chronic implementation difficulties.

Their successful adoption will require demonstration of how they work in practice, accompanied and followed by appropriate capacity building and awareness raising, an important focus- and conclusion-defined in this study. Based on the WRMA, all nine basin authorities are currently in the process of setting up new water governance regimes. These include the establishment of Water Use Associations (WUAs) and Water Use Groups (WUGs). Out of the nine river basins covering the whole country, only five basins have basin authorities. The remaining four basins which include the Internal Drainage Basin Authority (IBDA) (governing the Manyara basin) do not have River Basin Offices and as a result we believe that integrated water resources management is difficult to coordinate and implement. Most smallholder irrigators, livestock keepers do not pay for the water they use (Ngana et al., 2004), hence showing a decoupling between use and value. The major drainage systems in this basin include: Lake Eyasi System, Lake Manyara System and Bubu complex. The Manyara National Park is managed by TANAPA. Manyara Biosphere Reserve (BR) involves several stakeholders who are streamlined into existing government structures. Through the growing connections, cooperation and collaboration has increased between the BR, stakeholders and the community. The existing networks are Tarangire Manyara Ecosystem Working Group (TMEWG), District Consultative Committee (DDD) and regional Consultative Committee (RCC). These forums usually meet on quarterly basis.

The suboptimal outcome of current governance and the unclear priorities may be linked, amongst others, to the fact that the Manyara basin has no own water board like e.g. the adjacent Pangani basin and the associated integrated water management project. Moreover, the Manyara catchment basin is managed by different authorities according to overlapping spatial and functional scales (respectively TANAPA for the National Park, IDBA and several associated ministries). This can lead to discrepancies in management options, e.g. conflicts of interest between food security, cash crops, subsistence economy, pastoralism, biodiversity conservation and tourism. This leaves the door open to a grey zone of interpretation and enforcement and may result in corruption and land use abuse. Hence there is a need for a more comprehensive Decision Support System, not only integrating the different governance levels and scales, but governing with clear mandates and allocating transparent land-water use zonings and quotas.

4.4. Towards an integrated and informed management of the Lake Manyara social-ecological system

National and international resources for an integrated approach of the whole basin should be mobilized. More multi-stakeholder workshops to formulate updated recommendations are not so much needed (they already exist), but foremost, it is time to integrate and implement the existing recommendations into a holistic and multiscale design of Decision Support System (DSS) and an operational integrated basin management. Local best practices such as 'participatory land use planning' (Ujamaa Community Resource team, 2010) could show the way.

The analysis pinpointed the following axes to be prioritized: water, stakeholders and governance (including policies and land use management such as cattle grazing and wildlife). These three modules should shape a DSS as they would allow open and transparent negotiations on trade-offs. A DSS ideally combines decision analysis and information modules (Gough & Ward, 1996). Moreover, clear management options would transversally link ecology and socio-economics of the whole Manyara basin. Compartmentalisation of interests should be avoided as well as the maintenance of informal strategies including hidden agendas. One way to develop a DSS is to promote the use of rapid assessment methods for the valuation of ecosystem services (Bagstad et al., 2013). Many of these methods link exact and social sciences and approach the ecosystem in an integrative, participative and inclusive way. A recent review identified the TESSA tool (Peh et al, 2013) as one of the most user-friendly and promising tools in that respect, and this study in fact contains many elements of TESSA,

in particular its preliminary scoping appraisal tool (Hugé et al., in review). African lakes such as Lake Manyara, would benefit from such approach.
Dynamic modeling (system dynamics approach) is a powerful set of tools to assess different future scenarios. It is especially appropriate for integrated water resources management (e.g. Awmi and Heidarzadeh, 2013) . Too many different socio-economic variables prevent from developing a simple model. The present study situates upstream from the development of dynamic models by offering building stones for developing such models in the future. Such models can only help if the socio-economic aspects are taken into consideration. The development of a DSS could contribute to break deadlocks, to handle 'wicked problems', and defuse latent conflicts by installing equitable and transparent trade-offs and benefits. Research from 30 years ago already suggested that Lake Manyara is more productive in terms of foreign currency production (tourism), compared to many agricultural crops, such as sisal and rice (Prins, 1987). Rights and plights, possible new 'Payment for Ecosystem Services' (PES) schemes should be developed to implement a workable integrated management based on scientific evidence and recommendations. Some interesting PES schemes were installed by TANAPA, such as the Community Conservation Service (CCS) and Support for Community Initiative Program (SCIP). Both programmes aim at involving the local community by sharing tourism benefits with them and improving their livelihood to gain their support in nature conservation (Kihwele and Moronda, 2004, Njole, 2011). However, the impacts of initiatives to install such multi-stakeholder schemes are difficult to measure (Ngana et al., 2003, Njole, 2011) and the distance or spatial connection between the location of ecosystem service provision and the benefits to the population is often an important factor influencing or hampering these schemes (Bagstad et al., 2013).

Key conclusions

This study aimed at a better understanding of the environmental issues at stake in the lake Manyara basin and the perception about it. We realised thet the social-ecological system of Manyara is characterized by many stakeholders with interests in freshwater (as a major ecosystem service) entering the lake, but few stakeholders directly interested in the saline lake water itself (ecological condition). However, all stakeholders mention tourism being under threat by the drying and sedimentation of the lake. So, consensus on the importance of tourism and the vulnerability of biodiversity is largely present and hence indirectly on the conservation of the lake. Our study benefited from inputs by smallholder farmers, pastoralists, scientists, development and conservation agencies, authorities and NGOs. However, some parties having an important financial stake in the basin were not present, being (1) the tourism industry and (2) large-scale agriculture. It is expected that the tourism industry will be favorable to conservation and that the intensive agriculture (situated south of the lake) will be rather neutral, as long as they are able to subtract enough irrigation water. Other threats are identified as well: privatization (legal and illegal) reduces the available grazing areas for pastoralists and wildlife thereby increasing conflicts between livelihood groups and between humans and wildlife. This in rurn influences (1) people's acceptance of conservation and (2) wildlife migration patterns. Our focus groups, interviews and the literature survey emphasized the importance of bylaws on land use and a more visible and fair redistribution of tourism benefits. Furthermore, the conflicting interests between different state policies such as the Water Act, the Irrigation Act and the Wildlife Act should be addressed. Despite ample grey and scientific literature this study pointed towards important scientific caveats, e.g. related to the aquatic ecology of the lake basin. This is linked to sedimentation, and its effects on the ichthyofauna and the fish-eating avifauna. Also, discussions with the stakeholders revealed that the fishing activities and its informal economy deserve a scientific cost-benefit assessment. The present study aims for a continued impetus to encourage all parties to mobilize adequate national and international policies and resources. This should be done in a context of trust (Young et al., 2016b) or 'honest advocacy' to develop a DSS with a holistic and transformative

vision. As evidenced in this study, this is the only pathway towards an operational integrated management owned by all stakeholders.

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