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Local perceptions on the state of the pelagic fisheries and fisheries management in Uvira, Lake Tanganyika, DR Congo

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ABSTRACT

The fisheries of Lake Tanganyika play an important role in food security in Central and Eastern Africa. Conservation of these valuable fish stocks will benefit from documenting the ideas, opinions and observations of stakeholders. Knowledge of the perceptions and an understanding of the concerns and

Abbreviations: ANOVA, analysis of variance; AU-IBAR, African Union – inter-African bureau for animal resources; AUC-NEPAD, African Union commission – new partnership for Africa's development; CPUE, catch per unit of effort; cAIC, consistent Akaike's Information Criterion; DRC, Democratic Republic of the Congo; PC, principal component; PCA, principal component analysis; LTA, Lake Tanganyika Authority; MANOVA, Multivariate Analysis of Variance; RMSEA, root mean square error of approximation; RMSR, root mean square of the residuals.

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struggles of stakeholders of these fisheries can provide policy-makers with recommendations for more suitable fisheries management. We did 1018 interviews with stakeholders, in one close-ended and three semi-open ended surveys. Factor analysis revealed seven clusters of opinions. Linear-mixed effects models identified common grounds and differences in opinions between groups of stakeholders about strategies in fisheries management. Stakeholders of the fisheries indicated challenges due to weather or climate variability, a noticeable decrease in fish abundance and size, and an increase in the price of fish. Fishermen experienced a lack of safety on the lake, including aggression and dangerous weather conditions, and hardly had access to safety gear and infrastructure. Landing site officials, state employees who monitor the beaches, mentioned capture of juveniles and declining catch-rates as the biggest threats to the fisheries. None of the groups of stakeholders attributed the problems in the fisheries to overfishing or overpopulation. We found similarities in opinions over a wide range of stakeholder groups, with many stakeholders asking for better and fair enforcement of existing legislation. State employees were more positive than the other groups towards creating more strict regulation of the fisheries. The results presented offer focuspoints for policy-makers to improve the management of the Lake Tanganyika pelagic fisheries.

Introduction

The inland fisheries of Africa provide a crucial and often underestimated source of food and income for millions of people in some of the world's least developed regions (AUC-NEPAD, 2014; Fluet-chouinard et al., 2018). This certainly holds for the fishery in the world's oldest and deepest tropical freshwater lake: Lake Tanganyika (East Africa, 03°20′-08°48′S/29°03′-31°12′E) (Coulter, 1991; Lake Tanganyika Authority, 2012; Poll, 1953; Roest, 1992). This ancient lake is well known for its unique biodiversity and its high levels of endemism (Salzburger et al., 2014; Snoeks, 2000; Van Steenberge et al., 2011). It is shared by four countries: the Democratic Republic of the Congo (DRC), Tanzania, Zambia and Burundi. Several large population centres are found along its shores, including Bujumbura (Burundi), Uvira (DRC), Kigoma (Tanzania), Kalemie (DRC) and Mpulungu (Zambia). In the last two decades, all of these urban centres have increased in population at an annual rate of 3–4% (Ogutu-Ohwayo and Balirwa, 2006).

The fisheries of Lake Tanganyika target multiple species with multiple types of gear (Lindley, 2000). The pelagic fisheries, the main focus of this paper, are centred around three species: two endemic clupeids: the Lake Tanganyika sprat *Stolothrissa tanganicae* Regan, 1917, and the Lake Tanganyika sardine *Limnothrissa miodon* (Boulenger, 1906), and their main predator: the sleek lates, *Lates stappersii* (Boulenger, 1914) (Mölsä et al., 2002). Additionally, the littoral fishery targets juvenile *L. miodon* and demersal cichlid species (Mushagalusa et al., 2014; Petit and Shipton, 2012). In the North of the lake, clupeid and *Lates* fisheries use so called 'apollos'. These apollos consist of two wooden boats, connected with wooden beams, and are manned by a team of four to six fishermen. These teams of fishermen fish at night using a lift-net, and use a light source to attract schools of pelagic fish. In the littoral fisheries, fishermen mostly use beach seines, gillnets and hook and line (Mushagalusa et al., 2014; Petit and Shipton, 2012). These littoral fisheries are often carried out by women and children, and operate with unregulated gear.

Fisheries legislation of the DRC is regulated top-down, dates back to 1981 and has not been revised since. In the Lake Tanganyika fisheries, all fishing activities must be registered and fishermen are required to pay a registration fee of USD 20 annually. The minimum allowed mesh size for lift-nets is 4 mm, and it is illegal to discard fish catches. Industrial fishing, i.e. fishing with units whose combined length of fishing nets exceeds 2500 m, is forbidden within 5 km of the shoreline (Petit and Shipton, 2012). Each landing site has four landing site officials, two of the department of fisheries, and two of the department of agriculture, who are responsible for monitoring and enforcement of fisheries regulations. Compliance with fisheries legislation is, however, low in the DRC. This is mainly due to a limited capacity for enforcement and a lack of involvement of stakeholders in the formulation of legislation (AU-IBAR, 2016). Common illegal practices include fishing from prohibited landing sites, fishing without a license, fishing with mosquito nets, and fishing too close to the shore (McLean et al., 2014; Petit and Shipton, 2012). Fishing with mosquito nets is the only means of access to the littoral fisheries resource for a part of the population (Bush et al., 2017; Short et al., 2018), especially impoverished women (Short et al., 2020). However, this illegal gear targets juvenile fish (Petit and Shipton, 2012), potentially contributing to food insecurity and increased poverty (Jones and Unsworth, 2020). The illegal catch of juvenile *L. miodon* causes an estimated economic loss of USD 2.1 million annually (Mulimbwa et al., 2018).

At several sites, littoral fish habitats are being disturbed by the extraction of sand and gravel. Runoff, caused by the clearing of land for agriculture, and the extraction of wood for fuel and building materials, has further affected the littoral zones by increased sedimentation (Nkotagu, 2008; Plisnier et al., 2018). Additionally, untreated wastewater flows into the lake (Plisnier et al., 2018), depositing pollutants and causing local eutrophication (Nkotagu, 2008). Conversely, climate change has led to a warming of the upper water layer and increased stratification (O'Reilly et al., 2003; Kraemer et al., 2015), reducing productivity and increasing transparency (Stenuite et al., 2007; Verburg et al., 2003). There are also reports of decreased wind speeds, further increasing stratification (O'Reilly et al., 2003; Plisnier, 2000). All of the above changes can have negative effects on the fish stocks.

The territory of Uvira is situated at the northern end of the lake, and contains one of the lake's largest population centers, the city of Uvira. Increased population pressure, increasing demand for protein, and a lack of employment has led to an increased number of fishermen, both legal and illegal, intensifying pressure on the fish stocks (Mulimbwa, 2006; Petit and Shipton, 2012; Van der Knaap et al., 2014). There are reports of a decrease in catch-rates (the catch by weight per effort spent fishing) at the northern end of the lake of the larger *Lates* (van Zwieten et al., 2002) and the clupeid species (Mulimbwa, 2006; Sarvala et al., 2006). These decreases may be linked to increased fishing pressure and changes in climatic factors (Kolding and van Zwieten, 2012; O'Reilly et al., 2003). However, efforts to document the total catch and catch per unit effort (CPUE) have been sporadic and inconsistent (Plisnier et al., 2018), making assessment of catches and fisheries-potential speculative (Kolding et al., 2019).

Due to the economic and nutritional importance of the fish resources to the coastal population, proper management of the fisheries of Lake Tanganyika is crucial. Protection of the fisheries implies a clear definition of the management objectives and clarification of management priorities. The objectives of management need to be chosen in relation to (perceived) problems as voiced by local communities. Whatever objective is chosen to be central, sustainable management requires the enforcement of effective regulation with the support of the local communities (Van der Knaap et al., 2014). Involvement of local communities in environmental management is also one of the cornerstones of the Aichi biodiversity targets, the United Nations plan of action for conservation of biodiversity (Convention on Biological Diversity, 2010) and is mentioned in its national report of the DRC (MEDD, 2019). Formulating and implementing fisheries regulations without considering opinions and concerns of fishermen and other stakeholders may have adverse effects. Previous research (Branch et al., 2006) shows that, for example, closed seasons can encourage fishermen to catch more during the open season, forbidding one type of gear can encourage usage of new types of unregulated gear, and limiting entry into the fishery can encourage those who have entered to maximise their effort.

Differences in types of interaction with the resource lead to differences in viewpoints between groups of stakeholders, which will influence their support for specific management measures. Fisheries scientists and policymakers tend to emphasize a direct link between management measures and fish stocks. Fishermen on the other hand put more emphasis on the unpredictability of nature, and less on the effect management measures have on fish stocks (Verweij and van Densen, 2010). Fishermen will rely on information of a smaller temporal and spatial scale, being their own experience and that of colleagues and relatives, while scientists and policymakers integrate information from larger temporal and spatial scales, thus revealing patterns at those scales that are masked by variability at smaller scales (van Densen, 2001). To improve gender equity in decision making, knowledge of the opinions and practices of both men and woman is valuable. Perspectives might differ (Barclay et al., 2017). If, for example, regulations were formulated with mostly the interest of men in mind, men would be expected to be more positive towards existing legislation. Fisheries practices mainly carried out by women, like mosquito net fishing, might be overlooked and therefore not be included in the legal framework (Kleiber et al., 2015). On the other hand, these practices might, therefore, be ignored by enforcement.

Interviews with stakeholders are a valuable tool to provide knowledge for conservation purposes and fisheries management (Bergmann et al., 2004; Zukowski et al., 2011). They can supplement other types of research such as monitoring of catch (Young et al., 2018). Interviews can also be useful to understand human behaviour and motivations in the context of conservation, especially when complex behaviour is involved (Cepić and Nunan, 2017), as is the case in fisheries. They can further serve as a measure for public awareness and for the willingness to support fisheries management strategies (Bodin et al., 2016; Pomeroy, 2016). Stakeholders can provide information about changes that have occurred in an ecosystem (Martins et al., 2018), identify problems and suggest alternative solutions (Wilson et al., 2006).

To gain an understanding of the challenges faced by the stakeholders of the fisheries of Lake Tanganyika, we asked them about perceived problems in the fisheries as well as their views on effective solutions to these problems. Through interviews, we aimed to gather stakeholder observations on the fisheries, related to changes in catches, abundance, and sizes of fish, as well as changes in the ecosystem, stakeholders' opinions on these observations, and related conservation and management issues. We reveal motivations of fishermen to enter and remain in fisheries. Regarding preferred management interventions, we expected that fishermen would have a less positive attitude towards stricter fisheries regulation than state employees. As current regulations may have a gender bias we tested if men appreciate current fisheries management measures more than women.

Material and methods

Data collection

Stakeholders of the fisheries were defined as those who are directly or indirectly influenced by the pelagic fisheries in and around the territory of Uvira, through fisheries related employment or regular consumption of fish. This implies that a large part of the inhabitants of Uvira were considered as stakeholders. The interviewed stakeholders covered a wide range of interactions with the resource and encompassed different social and political positions (authority). We considered three groups of stakeholders: a broad group of all stakeholders of the fisheries, including but not restricted to fishermen and landing site officials, a separate second group of only fishermen, and a third group of only landing site officials (Fig. 1). The broad stakeholder group was chosen to represent all those dependent on the fisheries. Additional interviews were done with fishermen only because of their large interest in and influence on the resource. Fishermen were defined as people who have pelagic fishing as main source of income. Landing site officials are employees of the state who monitor fisheries practices and collect fisheries statistics on the different landing sites. Additional interviews were held with these landing site officials because of their experience with the fisheries. To include all the main markets and landing sites in the area, interviews were conducted at 25 locations (Fig. 2, Electronic Supplementary Material (ESM) Table S1). The study sites were chosen based on the expectation to find respondents, and to achieve an optimal geographical spread to reduce various biases based on geography, or location.

Four questionnaires were developed: one questionnaire with closed statements for all the stakeholders of the fisheries and three semi-open ended interviews, one for all the stakeholders of the fisheries, one for fishermen specifically, and one specifically for landing site officials (Table 1, ESM Table S2). Development of questionnaires was a participatory co-production by researchers and officials connected to these fisheries, encompassing 25 scientists and students, 4 officials and 6 NGO representatives. Together they decided on the content and formulation of questions, selected which groups of stakeholders would be interviewed and selected locations. In total, 32 interviewers interviewed stakeholders over

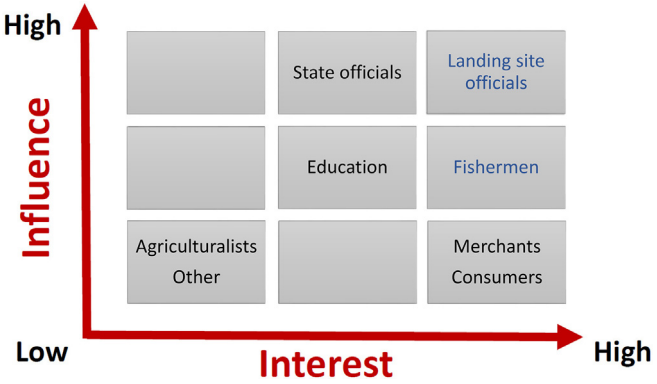

Fig. 1. Stakeholder groups included in the survey, which we ranked according to the interest in and influence we assume them to have over the fisheries of Lake Tanganyika. Groups with which additional interviews were done are indicated in blue.

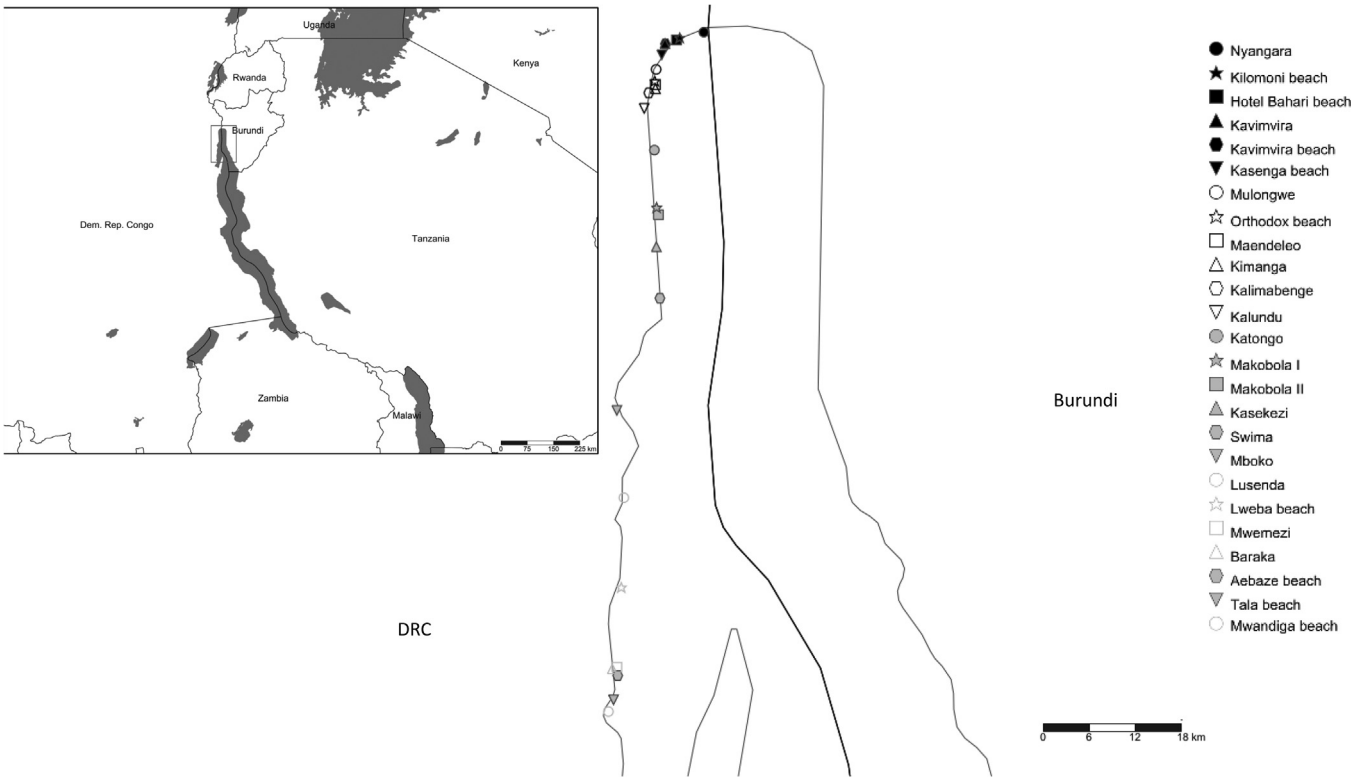

Fig. 2. Map indicating the locations of the interviews. Made with simplemappr (www.simplemappr.net). Coordinates of the locations are shown in ESM Table S1.

Table 1
Overview of interviews. Columns show which type of stakeholders was interviewed, which type of questionnaires were used, the content of the questions and the total number of respondents (n).

Respondents	Type of questionnaire	Type of questions	n
All stakeholders	Close-ended	26 statements about management options	561
All stakeholders	Semi open-ended	Observed changes in ecosystem and fisheries resources, importance of fish as food source	196
Fishermen	Semi open-ended	Motives, economic alternatives, importance of fisheries, observed changes	229
Landing site officials	Semi open-ended	Perceived problems and preferred management options for Lake Tanganyika fisheries	32

a three-day period in August 2018 and over a three-day period in October 2018. Each interview was conducted and recorded by two or three interviewers and notes were compared to increase reliability of recording. The interviews were constructed in French, and interviewers asked the questions in French or Kiswahili.

Opinions of all stakeholders on management strategies

A close-ended survey, consisting of Likert scale (1 totally disagree – 5 totally agree) questions about fisheries management and statements related to the ecosystem of Lake Tanganyika (Table 2) was done with 561 stakeholders of the fisheries (187 female and 370 male). Respondents represented all stakeholder groups of the fisheries as described above (broad stakeholders group). Respondents were grouped into six categories according to the profession they indicated: fishermen (n = 233), merchants (n = 130), state officials (n = 31), education (teachers and students) (n = 42), agriculturalists (n = 64) and other (n = 61). For an overview of professions included in each of the categories, see ESM Table S3. We classified these groups in relation to the effect members can have on the fishery (influence) and to the importance of fisheries in the lives of the respondents (interest) (Fig. 1). The purpose of this survey and subject population was to assess opinions of stakeholders on fisheries- and lake-related issues and possible management options, and to identify differences and similarities in opinions between different groups of stakeholders. Interviewees were chosen by addressing people on a successive encounter basis at landing sites and at places where fish is bought and consumed, such as fish markets, hotels and restaurants. Additional sampling was done in the same way at government offices and at schools to address state employees, students and educators.

Semi-open ended questions for all stakeholders

A second questionnaire aimed at the same groups as the previous questionnaire: i.e. all of the stakeholders of the fisheries, consisting of semi-open ended questions, informed about observed changes in the ecosystem, observed changes in the quality and availability of the resource, and about the availability of fish as food source. There were 196 respondents, of whom 91 were men and 104 women; grouped according to main profession, we interviewed: 38 fishermen, 66 merchants, 9 state officials, 3 teachers and students (education), 38 agriculturalists, and 42 other.

Semi-open ended questions for fishermen

A semi-open ended questionnaire with 229 fishermen was used to: identify motives for choosing the profession of fisherman;

Table 2
Close-ended questionnaire with stakeholders of the fisheries: average score per question for the different professional categories. n = number of answers given. Significant differences ($p < 0.05$) in responses between sexes and groups of stakeholders, tested with type III Wald F statistics, and post-hoc Tukey contrasts for professions, after a linear mixed-effects model eliminating the effect of different interviewers are indicated. Stakeholders are grouped into six categories: agriculturists (a), fishermen (f), merchants (m), education (e), state employees (s) and other (o). Sexes are male (M) and female (F).

ID	Question	n	mean	Difference
Q01	The fishery should be closed a few months per year	557	2.96	
Q02	Fishing gear must be regulated	557	3.50	F < M afm < e
Q03	Deforestation around the lake must stop	557	4.03	
Q04	Aquaculture is a good alternative to fisheries	555	3.91	
Q05	Stricter measures must be taken against illegal fishing	556	3.78	
Q06	Control institutions should receive more staff and more money	556	3.65	F < M f < o
Q07	Scientists must gather more information on fisheries	556	4.03	
Q08	The number of people who can participate in fisheries must be regulated with a fishing license	557	3.03	afo < s;f < e
Q09	There are too many fishermen, which leads to overfishing	556	2.68	
Q10	There is overpopulation, which leads to overfishing	557	2.82	
Q11	Local communities should be involved in resource management	555	3.74	
Q12	Parts of the lake must be closed to fishing permanently	555	3.27	F < M
Q13	Spawning sites (river mouths, bays, etc.) must be completely closed to fishing and human activities	555	3.93	
Q14	Everyone must stop catching juvenile fish	555	3.67	F < M
Q15	The government must exercise more control over the fisheries	555	3.84	a < e
Q16	The four countries around the lake need to cooperate more in sustainable fisheries management	557	3.87	
Q17	Pollution of the lake (bags, plastic bottles, household waste ...) has a negative effect on fishing	557	3.88	
Q18	The exploitation of sand and stones has a negative effect on fishing	557	3.47	
Q19	The government must teach better fishing methods to the population	556	4.04	m < e
Q20	The absence of alternatives increases the number of fishermen	557	3.88	F < M ef < a
Q21	If there was easy access to practical education, people would have more alternatives for fishing	422	3.97	F < M
Q22	The number of fishing gear that each fisherman can use must be limited	420	3.01	
Q23	There is too much fish on the market that comes from outside the territory of Uvira	421	3.00	
Q24	If it were safer to farm, it would be a good alternative for fishing	421	3.66	
Q25	We must close or prohibit fishing in places which have potential for tourism	420	3.37	F < M
Q26	We must stop fishing in the littoral zone	412	3.31	

identify their preferred management strategies; assess the economic importance of the fisheries to the fishermen; and record their perceptions of changes in the lake's ecosystem and fisheries output. All respondents were men.

Semi-open ended questions for landing site officials

Uvira has 56 landing site officials at 14 landing sites, with each site hosting four officials, two from the department of fisheries and two from the department of agriculture. Officials spend much time on the landing sites monitoring the fisheries. They are the link between fishermen and the government, and are well informed about difficulties faced by both fishermen and monitoring institutions. We conducted group interviews with 38 landing site officials to learn about perceived problems and preferred management options. In two group interviews, 21 officials from agriculture and 17 from fisheries, were interviewed separately at the offices of their respective government departments. Each group was interviewed collectively and asked two questions: 'what are the current problems for the fisheries in Lake Tanganyika?' and 'what are the solutions for optimal management of the Lake Tanganyika fisheries?'. Respondents were given time to reflect and then stated their responses one after the other. The responses to this questionnaire are illustrative of the problems and solutions proposed by landing site officials, rather than an exhaustive list.

Data analysis

For the closed statements, average Likert scores per question were calculated for the different categories of stakeholders. To visualize how different professional groups differ in their answers to the questionnaire, a biplot based on principal component analysis (PCA) was constructed using the Factoextra package in R (Kassambara and Mundt, 2017). Separation of professions on the PC axes was tested with ANOVA (stats package in R, R Core Team, 2018). To identify differences between professions and sex, and interactions between sex and profession on responses to the 26 statements, we used a linear mixed-effects model, following the guidelines of Zuur and Ieno (2016), using the lme4 package in R (Bates et al., 2015). We modelled the scores on the 26 questions as a function of sex and profession and the interaction sex*profession. To eliminate the influence different interviewers had on the results, we added interviewer as random variable. The response variable was coded on a 1–5 Likert scale. We used a model assuming Gaussian distribution. The best model was identified using backwards selection, retaining the model with the lowest consistent Akaike's Information Criterion (cAIC), using the stepcAIC function of the cAIC4 package in R (Saefken et al., 2018). Fixed effects (sex and profession) were tested using type III Wald F-tests (Kodde and Palm, 1986). If the F-tests indicated significant differences between the professional groups, multiple comparisons of means with Tukey contrasts were used to find which pairs of professions differed significantly, corrected for multiple testing with Benjamini-Hochberg p-value adjustment (Benjamini and Hochberg, 1995), using the multcomp package in R (Hothorn et al., 2008).

Factor analysis (FA) was used to group questions that were answered in a similar way. To find the optimal number of factors, we used parallel analysis. This technique compared the eigenvalues of the data to eigenvalues of simulated random data, and returned the lowest number of factors for which eigenvalues were significantly greater than those obtained from the simulated data (Horn, 1965). We used minimal residuals FA (Comrey, 1962), followed by varimax rotation, an orthogonal rotation method that maximizes the variance of the loadings for each question on the factors while keeping the factors uncorrelated (Kaiser, 1958). As a quality check of the FA, we calculated the Tucker Lewis index, the root mean square residual (RMSR) and the root mean square error of approximation (RMSEA). The Tucker Lewis index is an estimate of the discrepancy between the final FA, and a simulated null model (Tucker and Lewis, 1973). A Tucker Lewis index of 0.95 or above indicates a good fit. RMSR is the average square root of the

discrepancy between the sample covariance matrix and the FA covariance matrix. Values for the RMSR range from 0 to 1, with a lower measure indicating a better fit of the FA with the data. Values below 0.08 are considered a good fit (Hu and Bentler, 1999). The root mean square error of approximation (RMSEA) is a comparable measure, but with optimization of parameters. Here, values below 0.06 indicate a good fit (Hu and Bentler, 1999). These analyses were done using the psych package in R (Revelle, 2018). Factors were interpreted by analyzing the statements in each factor, weighed by their contribution to the factor. To find the contribution of profession and sex on scores on the factors, we used a linear mixed-effects model with interviewer as random variable in the same way and with the same model selection process as discussed above. All analyses were performed using R 3.5.2 software (R Core Team, 2018).

For the three open-ended questionnaires (Table 1), responses were coded into categories in a three-step process, following the protocol outlined by Bryman (2008). First, each response was coded into categories based on meaning. Responses that had the same meaning but were differently phrased were treated as the same. In a second stage, answers were merged into overarching categories. The number of times a response was given, and the percentage to the total was calculated. In the last stage, answers were ranked according to occurrence, removing all response categories that were less frequent than 3%. Analyses were performed in Microsoft Excel.

Results

Opinions of stakeholders on management strategies

Average Likert score was calculated per question (Table 2, ESM Fig. S1). Overall, respondents agreed most with the following statements: 'The government must teach better fishing methods to the population' (Q19); 'Deforestation around the lake must stop' (Q03); and 'Scientists must gather more information on fisheries' (Q07). Respondents disagreed most with: 'There are too many fishermen, which leads to overfishing' (Q09); 'There is overpopulation, which leads to overfishing' (Q10); and 'The fishery should be closed a few months per year' (Q01). The PCA on the answers to the 26 questions revealed only limited separation of the respondents on the first three PC axes (Fig. 3). This indicates a high level of agreement between respondents on most of the statements. The first PC correlated strongly to the 1–5 scale on the questionnaire. State officials, people in education and the 'other' group scored higher on this axis (ANOVA, $F(5, 555) = 13.59$; $p < 0.01$), indicating that in general, they agreed more with the statements than the other groups. The second axis slightly separated fishermen from the other groups ($F(5, 555) = 11.95$; $p < 0.01$) (Fig. 3A). There was also a significant separation on PC3 ($F(5,555) = 2.53$, $p = 0.03$) (Fig. 3B). Based on cAIC, for each of the questions separately, the model without the interaction term was selected: Response ~ Profession + Sex + (1| Interviewer). Reports of the regression parameters of the model and the ANOVA on the model for each question can be found in ESM Table S4 and ESM Table S5 respectively. Linear mixed-effects models revealed significant differences between professions and sexes for 10 of the 26 questions. Differences that were significant using F-tests (for sex, since we recorded only two levels for sex) or post-hoc Tukey contrasts (for professions) are indicated in Table 2 and ESM Table S6. State officials and people in education agreed more with the statements in the closed-ended questionnaire than fishermen and agriculturalists. This difference was especially pronounced on the statements asking for more licensing and more government control and for regulation of fishing gear (ESM Fig, S1, Table 2).

Parallel analysis grouped the questions into seven factors together explaining 39% of the variance in the data (Table 3, Fig. 4). The Tucker Lewis index of factoring reliability was 0.89, which is below the optimally suggested value of 0.95, (Tucker and Lewis, 1973). The RMSR was 0.03 and RMSEA index was 0.043 (90% CI: 0.035–0.048), well below the maximally acceptable values of 0.06 and 0.08 respectively (Hu and Bentler, 1999). Although the low Tucker Lewis index might indicate a mismatch between the model and the data, it was still deemed acceptable as the RMSR was below 0.06 (Hu and Bentler, 1999). Factor one explained 9% of the variance in the data. It grouped the statements about limiting access to the fisheries, by closure of parts of the lake for fishing and by limiting the number of gear a fisherman can deploy. This factor also included statements asking for research to gather more information on the fishery and about the potential alternative of aquaculture. The second factor (6% of variance) combined statements about more action from the government by increasing cooperation between the four riparian countries (Q16), exercising more control over the fisheries (Q15) and teaching better fishing methods to the population (Q19). This factor also included statements about providing more staff and money for control institutions (Q06), and more involvement of local communities in resource management (Q11). The third factor (6%) grouped statements about enforcement of existing legislation: regulations of fishing gear (Q02), stricter measures against illegal fishing (Q05) and the catch of juvenile fish (Q14), and enforcement of the closing period (Q01). Each of the other factors explained less than 5% of the variance. The fourth factor was about too much fishing activity, and the fifth factor highlighted the negative effects of environmental degradation. Factor six combined statements about a lack of alternatives for fishermen and the last factor consisted of a singular statement about safety for farmers.

After backwards model selection, retaining the model with lowest cAIC, the model that was selected for each factor was the one with sex and profession as fixed effects, and interviewer as random effect: Factor ~ Profession + Sex + (1| Interviewer). Reports of the regression parameters of the model and the ANOVA on the model for each question can be found in ESM Table S7 and ESM Table S8 respectively. Significant differences were found between different professions (Fig. 4) and sexes in two of the factors (Table 3, ESM Table S7). Men scored significantly more positive than women on two factors: call for more action from the government (factor 2: ANOVA, $F(1, 529) = 8.17$, $p < 0.01$), and lack of alternatives (factor 6: $F(1, 530) = 12.5$, $p < 0.01$). There is a trend ($p < 0.1$) of men scoring more positive on factor five, negative effect of environmental degradation. State employees scored more positive than the other professions on the call for more action from the government (factor 2: $F(5, 540) = 2.50$, $p = 0.03$). On factor one (limiting fishing effort) there is a trend ($p < 0.1$) of fishermen scoring less positive than the other groups. On factor three, enforcement of existing legislation, there is a trend towards state employees, people in education and people in the other group scoring more positive than the other groups.

Semi-open ended questions for all stakeholders

In a questionnaire aimed at all stakeholders of the fisheries, we asked the respondents whether they had noticed any changes in the lake, or the fish. The most frequent answers were linked to climate or weather effects (strong winds, more rain) and effects of eutrophication (green color of the lake) (Table 4). Of the respondents, 23% said almost all species of fish on the market were becoming smaller. It was reported that fish quality was lower than

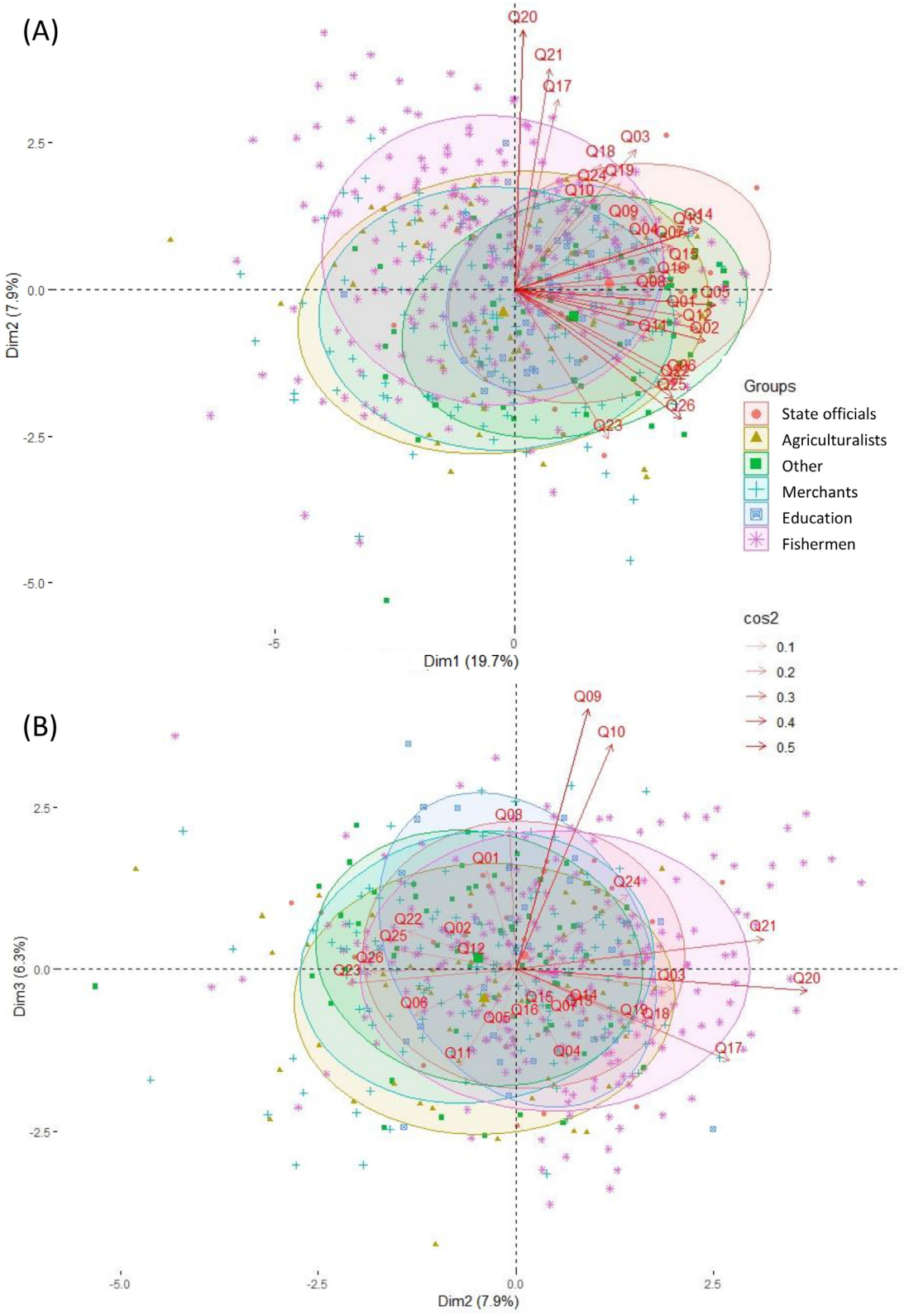

Fig. 3. Biplot of the PCA conducted on the responses of the closed-ended questionnaire. Symbols indicate the six groups: agriculturists, fishermen, merchants, education, state officials and other, and ellipses indicate the 75% confidence interval. With (A) PC 1 (19.7%) *vs.* PC2 (7.9%) and (B) PC2 *vs.* PC3 (6.3%). For an overview of the questions (Q1-Q26), see Table 2.

Table 3
Factor analysis of the close-ended questionnaire with stakeholders of the fisheries: grouping of questions into seven factors and loadings for each question on their respective factor. Significant differences ($p < 0.05$) in responses between sexes and groups of stakeholders, tested with type III Wald F statistics, and post-hoc Tukey contrasts for professions, after a linear mixed-effects model eliminating the effect of different interviewers are indicated. Professions are grouped into six categories: agriculturists (a), fishermen (f), merchants (m), education (e), state employees (s) and other (o). Sexes are (M) male and (F) female.

Factor	Questions and their loadings on the factor			Difference
Factor one: limiting fishing effort (9%)	Q26	We must stop fishing in the littoral zone	0.6	
	Q25	We must close or prohibit fishing in places which have potential for tourism	0.5	
	Q12	Parts of the lake must be closed to fishing permanently	0.5	
	Q22	The number of fishing gear that each fisherman can use must be limited	0.4	
	Q04	Aquaculture is a good alternative to fisheries	0.4	
	Q07	Scientists must gather more information on fisheries	0.3	
Factor two: call for more action from the government (6%)	Q16	The four countries around the lake need to cooperate more in sustainable fisheries management	0.6	F < M aefmo < s
	Q06	Control institutions should receive more staff and more money	0.5	
	Q19	The government must teach better fishing methods to the population	0.5	
	Q15	The government must exercise more control over the fisheries	0.4	
	Q11	Local communities should be involved in resource management	0.4	
Factor three: enforcement of existing legislation (6%)	Q02	Fishing gear must be regulated	0.7	
	Q05	Stricter measures must be taken against illegal fishing	0.5	
	Q14	Everyone must stop catching juvenile fish	0.5	
	Q01	The fishery should be closed a few months a year	0.4	
Factor four: too much fishing activity (5%)	Q09	There are too many fishermen, which leads to overfishing	0.8	
	Q10	There is overpopulation, which leads to overfishing	0.6	
Factor five: negative effect of environmental degradation (5%)	Q17	Pollution of the lake (bags, plastic bottles, household waste,...) has a negative effect on fishing	0.5	
	Q18	The exploitation of sand and stones has a negative effect on fishing	0.5	
	Q03	Deforestation around the lake must stop	0.4	
	Q13	Spawning sites (river mouths, bays,...) must be completely closed to fishing and human activities	0.4	
Factor six: lack of alternatives (4%)	Q20	The absence of alternatives increases the number of fishermen	0.7	F < M
	Q21	If there was easy access to practical education, people would have more alternatives for fishing	0.7	
	Q23	There is too much fish on the market that comes from outside the territory of Uvira	-0.3	
Factor seven: safety for farmers (3%)	Q24	If it were safer to farm, it would be a good alternative for fishing	0.6	

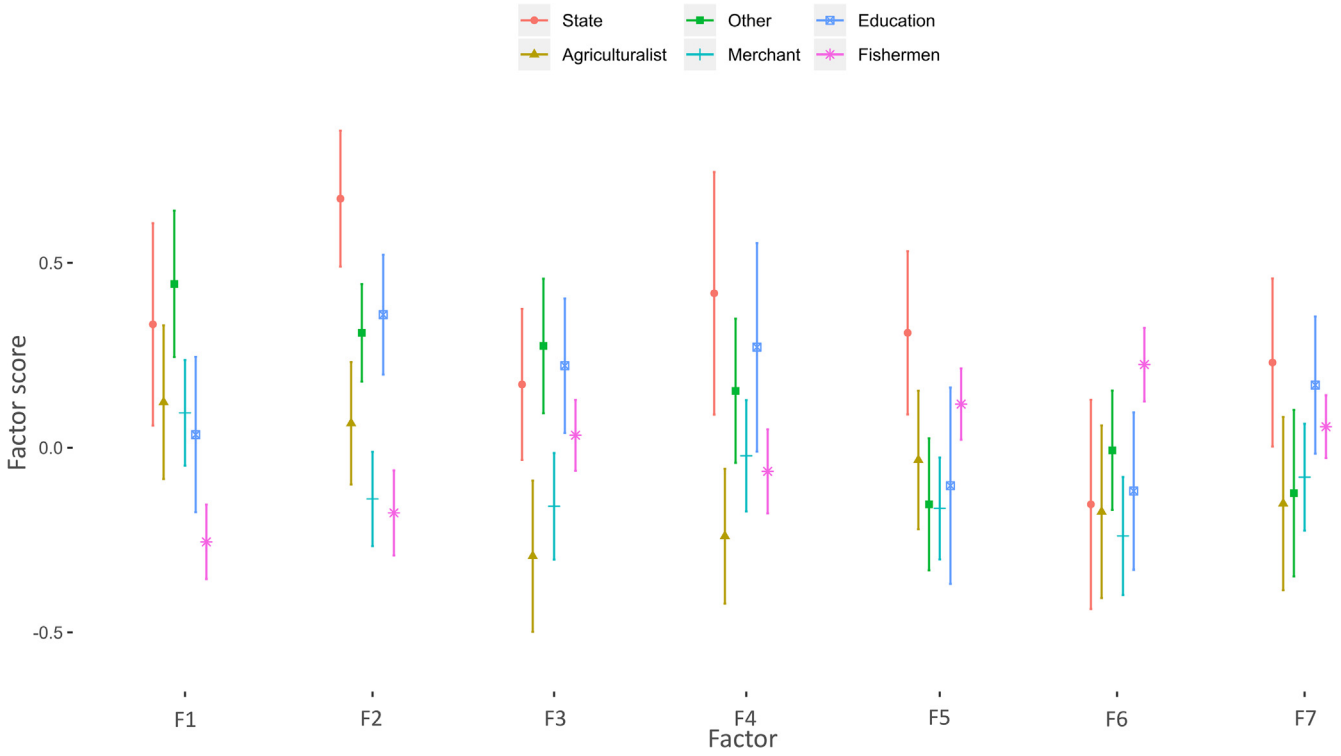

Fig. 4. Results of the factor analysis on the close-ended questionnaire with fisheries stakeholders with mean response and 95% confidence intervals on the seven factors for each of the six groups: agriculturists, fishermen, merchants, education, state officials and other.

before (Table 4). When asked if it had become more difficult to buy fish for the family, compared to other food, 67% replied yes, 28% reported no differences and 9% replied this fluctuated with the supply.

Semi-open ended questions for fishermen

Ages of respondents ranged from 18 to 78 with an average of 38.1 (sd +/- 13.3) and a median of 35. Experience as a fisherman ranged from 0.5 to 52 years, with an average of 15.6 (sd +/- 11.5) and a median of 12. The majority of the fishermen (57%) indicated having an additional livelihood to supplement their income from fishing. Most respondents (72%) also had other family members active in the fisheries. As a motivation for becoming fisherman, 69% of the respondents reported a lack of a more profitable source of income (Fig. 5A). The three main problems reported by fishermen were theft of fishing gear and harassment by gangs (44%), strong winds that caused dangerous waves (35%), and a decline in catch-rates (28%) (Table 5). As proposed improvement to the fisheries, our respondents suggested receiving of, or access to better, modern and regulated fishing gear (45%), better enforcement of the current fisheries regulation (39%), and assured safety for fishermen on the lake (27%) (Table 5). We also inquired about what limit of catch decline would be the turning point to leave the fisheries. Many fishermen (39%) replied that they would stop fishing when they would have no more profit from the fisheries. Some fishermen (26%) replied they would only stop when they would find different work or capital to finance a new profession. One out of five indicated they would continue fishing no matter how low their catches would become (Fig. 5B). When asked what they would do after quitting the fisheries, 33% replied that they would do nothing, either due to lack of alternatives or because of retirement. Agriculture was the most popular alternative to fisheries (28%), followed by trade (19%) (Fig. 5C). If our respondents would receive money to invest in their next profession, most would use it to invest in (fish) trade (62%) or fisheries (23%) (Fig. 5D).

Semi-open ended questions for landing site officials

The most frequently reported problems by landing site officials were fishing in spawning areas and capture of juveniles (n = 6) and a decline in catches (n = 5) (Table 6). Other problems included a lack of post-harvest processing opportunities, making unsold fish rot and thus go to waste (n = 3), that fishermen had outdated gear and no access to more modern gear (n = 3) and that there was pollution from households and industry (n = 3). As possible management solutions, landing site officials proposed a well-enforced closure of fisheries (n = 3), delimiting and closing spawning areas (n = 3) and streamlining fisheries legislation between the four different countries (n = 3) (Table 6).

Discussion

Opinions of stakeholders on management strategies

After assessing the opinions of the various stakeholders of the fisheries in Lake Tanganyika, stakeholders of different occupational groups showed similar opinions about management strategies, despite different involvement and interest in the fisheries. Our expectation that state officials would be more positive towards restrictive measures than fishermen, was confirmed. State officials also scored higher on the factor combining statements about strengthening government involvement in fisheries and increasing the enforcement of existing legislation. Because the questionnaires were developed by fisheries scientists and state officials, this might partially explain why these groups agree more with the statements. These state officials might have faith in the current rules and regulations because they have been taught these rules during training, and have been trying to enforce these. This faith in the current rules might partially explain why these groups agree more with statements that are in line with existing legislation. The livelihoods of resource managers, contrary to those of fishermen, are not directly affected by fisheries restrictions, which might also explain why the former were less opposed to restrictions (McClanahan and Abunge, 2016). As predicted, fishermen agreed less than other stakeholder groups that fishing effort should be limited, and indicated more than other groups that not enough alternative livelihoods to fishing were available. None of the respondent groups agreed to the statements that overpopulation or too many fishermen were causing overfishing. As expected, the factors where men scored significantly higher than women were those most associated with enforcing existing rules and regulations, such as

Table 4
Semi-open ended questionnaire with stakeholders of the fisheries: number of respondents is 196, n = number of times this response was given, % = percentage of this response in the total group. Respondents were allowed to give multiple answers.

Question	Response of stakeholders	n	%
Did you notice changes in the lake (wind, rain, colour, algae)?	Change in water colour	80	41
	Strong wind	69	36
	More rain	42	22
	Lake level higher	41	21
	No changes to report	27	14
	Yes (unspecified)	18	9
	Fluctuation in lake level according to seasons	11	6
	Rain brings garbage/ dirt to the lake	9	5
	Lower lake level	5	3
Did you notice changes in the fish (size, quality, taste, presence of worms)? In which fish?	No differences	54	28
	Almost all fish smaller	44	23
	All fish lower quality (rot fast)	23	12
	Mikeke (adult *L. stappersii*) smaller	27	14
	Lumbu (adult *L. miodon*) smaller	11	6
	Change in taste for fish caught with a gillnet	11	6
	Less kuhe (*Boulengerochromis microlepis*) sold at market	7	4
	Change in taste mikeke	6	3
	Karumba (adult *S. tanganicae*) smaller	5	3
	Ndagala* or nyamynyamu (Juvenile *L. stappersii*) smaller	9	5
	Kungura (*Limnotilapia dardennii*) tastes rotten	5	3

* Ndagala is a mix of adult *L. miodon* and *S. tanganicae*, and juvenile *L. stappersii*.

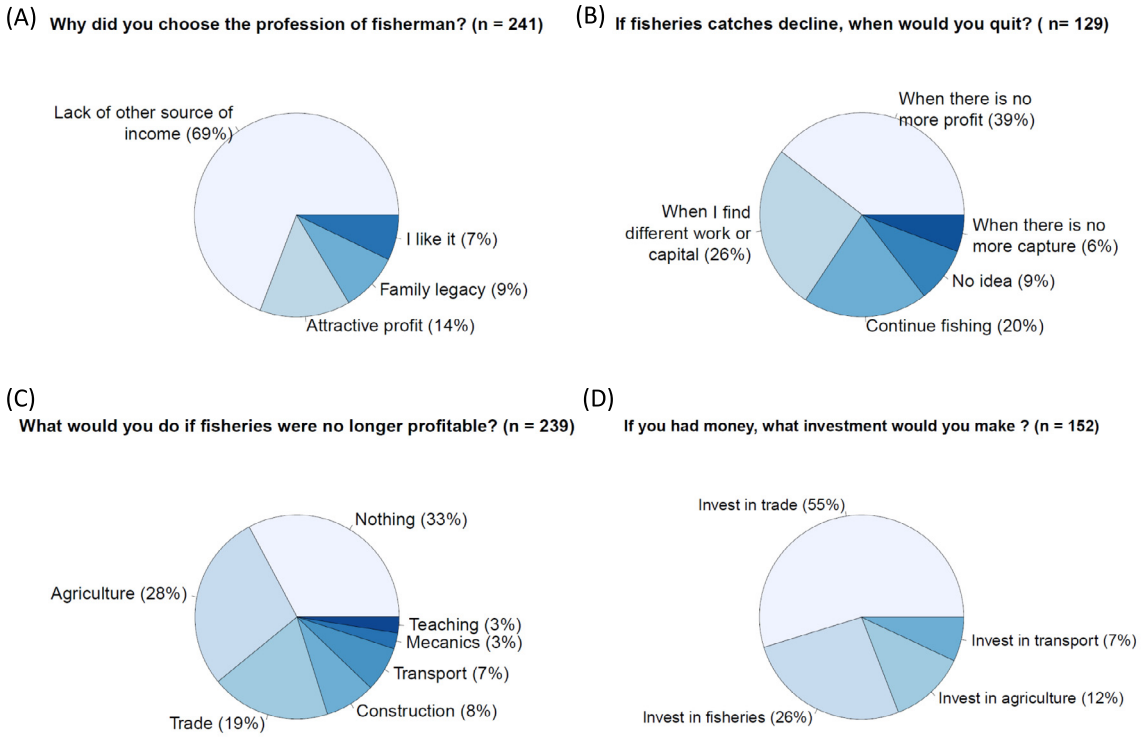

Fig. 5. Answers obtained in the semi open-ended questionnaire with fishermen. Responses to the questions (A) "why did you choose the profession of fisherman?" (Number of respondents = 241), (B) "If fisheries would no longer be profitable, when would you decide to quit?" (number of respondents = 129), (C) "What activity would you do if fisheries were no longer profitable?" (number of respondents = 239), (D) "If you would have money to create your next job, what type of investment would you make?" (number of respondents = 152).

Table 5
Semi-open ended questionnaire with fishermen: number of respondents is 158. n = number of times this response was given; % = percentage of this response in total group. Respondents were allowed to give multiple answers.

Question	Responses of fishermen	n	%
What problems are currently affecting you in your profession as fisherman?	Theft of fishing gear and harassment by armed gangs	67	44
	Dangerous winds that cause waves	53	35
	Declining catch	42	28
	Too many (illicit) taxes enforced by the army and the state	25	16
	Lack of (decent) fishing gear and clothing/ safety gear	22	13
	Attacks by wild animals (crocodiles and hippopotamus)	18	12
	There are no problems	8	5
	The patron does not pay (enough)	5	3
What is needed to improve fisheries?	More and better/ regulated materials and safety gear	71	45
	Enforce regulation of illegal fishing (gear)	61	39
	Assure safety on the lake for fishermen + action against armed gangs	42	27
	Financing through credit	28	18
	Formation of fishermen in fisheries techniques (workshops)	17	11
	Stricter fisheries legislation	13	8
	Financial support from government	13	8
	Forbid fishing of juveniles/ Forbid small mesh sizes	12	8
	Reduce taxes and stop military/government harassment	9	6
	Nothing/ I don't know	9	6
	Better adapted and enforced closing period	5	3
	Augmented catch	5	3
	Better understanding between patron and fishermen	4	3
	Services for fishermen on beaches (latrines, shelter,...)	4	3

gear restrictions and a ban on catching juvenile fish, and with more government control. These statements relate to the littoral fisheries, often dominated by women which, if current legislation was enforced, would be eliminated. In the past legislation has been based more on the experiences of men than those of women, and thus is better adapted to the needs and perceptions of men.

Changes perceived by stakeholders

A semi-open ended survey assessed perceived changes to the lake ecosystem. We expected that stakeholders would report changes in the lake ecosystem related to climate change. Stakeholders indeed indicated changes in rainfall, and in the level and

Table 6
Semi-open ended questions with landing site officials: number of respondents = 38. a = number of times a response was given by someone from the agriculture department (n = 21), f = number of times a response was given by someone from the fisheries department (n = 17).

Question	Responses of landing site officials	a	f
What are the current problems for fisheries in Lake Tanganyika?	Fishing in spawning areas and capture of juveniles	3	3
	Weak/ declining capture	2	3
	Lack of post-harvest processing, making unsold fish rot	2	1
	Fishermen have outdated gear and no better gear is available	2	1
	Pollution from households and industry	2	1
	Insecurity during fishing for fishermen (theft, threats, fear for life)	2	
	Fisheries services have difficulties controlling due to insecurity or lack of means	1	1
	Closing periods are not respected		2
	Strong winds cause dangerous waves, damaging fishing gear and boats	1	1
	Some beaches don't have latrines so fishermen defecate in the lake, which can contaminate the fish	1	
	Use of illegal fishing gear	1	
	Houses are built too close to the lake, reducing the beaches so that boats cannot land	1	
	No space to sell fish	1	
	Low oxygen in the water, fish asphyxiate	1	
	There is no shelter for the fishermen on the beaches	1	
	Fishermen are not experienced enough, so they do not catch enough fish		1
	Extraction of sand and stones		1
	Cutting of vegetation (like macrophytes), which destroys spawning areas		1
	Lates are close to extinction		1
What is needed for improved fisheries in Lake Tanganyika?	Close fisheries and enforce this closure	2	1
	Delimit and respect closing of spawning areas	2	1
	The four surrounding countries need to have the same restrictions in closing time and fisheries gear	1	2
	Provide new fisheries material that is conform the law	1	1
	Stop deforestation and start reforestation	1	1
	Forbid import of forbidden materials, it is well known where they come from		1
	Improve fisheries by giving a formation about the different techniques	1	
	Awareness raising among fishermen so that they understand the importance of fisheries regulation		1
	Stop building close to the lake, leave the littoral open	1	
	Give credit to fishermen so they can buy new materials	1	1
	Licensing for identification and reduction of number of fishermen	2	
	Construct cold chambers and equip fishermen with cooler boxes	1	
	Construct hangars for fishermen	1	
	Industrialization of fisheries will help catching bigger fish and will be easier to control	1	
	State should provide alternative livelihood so that people stop destroying the lake		1
	Forbid the extraction of sand and stones		1
	Make the neighbouring countries stop polluting the lake		1

colour of the lake. However, since these questionnaires were conducted at the start of the rainy season and after an intense algal bloom (personal observation, August 2018; Ndayisenga, 2018), many respondents might have been referring to recent changes. As the questionnaires did not specify a time scale for the observations, it was difficult to disentangle responses related to weather from those related to climate. It was surprising that respondents indicated more turbidity since, as a consequence of climate change, productivity in Lake Tanganyika has dropped, decreasing turbidity (Stenuite et al., 2007; Verburg et al., 2003). This is probably caused by respondents referring to a local scale, corresponding to their day to day experience. In Uvira, which is a densely populated area, eutrophication may have increased productivity locally, increasing turbidity. A similar phenomenon of locally increased turbidity around populated areas has been observed in Lake Victoria (Hecky et al., 2010). The effects of eutrophication would, however, be limited to the littoral, since cold runoff water would sink below the thermocline in deeper waters (Plisnier, 2000). In our survey, fishermen and other stakeholders indicated an increase in wind, contrary to temporal recordings, which showed no indication of any change in wind speed (Verburg and Hecky, 2009) or a decrease in wind speed (O'Reilly et al., 2003; Plisnier, 2000). Because these studies are more than a decade old, more recent data on wind speeds is needed. Possibly, respondents in our interviews who reported an increase in wind speeds witnessed these in the past months, as wind speeds are higher during the dry season (May-September) (Plisnier et al., 1999). Regular surveys with fisheries stakeholders could be used to better document this type of climate-variability. Collecting this data on larger time scales, and combining it with other measurements, will give a clear image of changes on local and regional scales, on different time scales, and the effects of these changes on the fisheries.

Stakeholders indicated that fish on the market were becoming smaller and that larger species were becoming rare (Table 4). They also reported that fish had become more difficult to afford compared to other food items. This observation corresponds to the observations made by fishermen, who indicated decreasing catch-rates, as discussed below. Because monitoring of Lake Tanganyika fisheries has been scant and fragmented (Kolding et al., 2019; Plisnier et al., 2018), and the government's enforcement capacities are limited, future management will benefit greatly from stakeholder involvement, to acquire information for stock assessment, and to increase consensus on issues related to resource use.

Fishermen's concerns

Fishermen reported as their main problem that fishing gear was often stolen and that they were often harassed by armed gangs. They reported a lack of safety gear such as life jackets, combined with dangerous weather conditions, such as high winds that cause waves. In many African artisanal fisheries, bad weather conditions are one of the leading causes of accidents for fishermen (Remolà and Gudmundsson, 2018). Due to a lack of weather warning systems in and around Uvira, fishermen are on the lake even under suboptimal weather conditions. Implementing an early warning system, such as on Lake Victoria, where a model predicts thunderstorms based on satellite data (Thiery et al., 2016), can potentially save many lives. In addition, fishermen reported attacks by crocodiles and hippopotami. Fishermen do not have radio communication, decreasing the chance of rescue after an incident (Ben-Yami,

2000). Landing site officials mentioned that the sites rarely feature shelter or sanitary facilities for fishermen, increasing the risk of contracting infectious diseases. Because of the high physical demands, fishermen need to be in good physical condition. Hence, the prevalence of infectious diseases might threaten their livelihoods (Béné and Friend, 2009).

As the third most often mentioned issue, about a quarter of the fishermen indicated a decline in catch-rate as one of their biggest concerns. Our survey shows that 72% of fishermen interviewed had multiple members of their families employed in fisheries. A declining catch-rate could have a serious negative impact on the incomes of these families, which are heavily dependent on fisheries, as alternative employment is scarce. Previous research showed perceptions of fishermen to be reliable indicators of changes in catch-rates (Rochet et al., 2008), although these perceptions are dependent on individual catch variability (van Oostenbrugge et al., 2002). Seasonal fluctuations might have caused temporarily reduced catch-rates, while the general trend remained steady (Kolding and van Zwieten, 2012; van Zwieten et al., 2002). The low catch season in the north of Lake Tanganyika falls between March and June (Kimirei and Mgaya, 2007). Because interviews took place in August and October, when catches are expected to be high, it is unlikely that stakeholders were reporting seasonal declines in catch-rate and resource availability. Despite reporting declining catch-rates, fishermen in our survey did not report that there was overfishing or overpopulation. Lake Tanganyika fishermen tend to see the fisheries as an unlimited resource. They do not attribute changes in catches to an increase in fishing effort, but to outdated gear, and to a switch to less bright lights to attract the fish. Note that recent research however, showed that the new LED lights were more efficient, which should lead to an increase in catch-rates (Mgana et al., 2019). The discrepancy between this finding and the experience of the fishermen merits further examination. We would expect fishermen to be in favour of management practices that are in line with the perception they have of fish abundance. Indeed, in our survey, fishermen do not support more strict catch restrictions, corresponding to their viewpoint that there is no overfishing, so there is no use for further restricting catches. They did show a large willingness to participate in existing fisheries management and asked for better and fair enforcement of existing fishing legislation, especially to eliminate the unfair competition from fishermen that operate illegally. Fishermen wished for a reliable governance system that protects them against aggressors, illicit taxes, harassment and theft, and fair enforcement of legislation.

The profession of many fishermen has an important historical and cultural significance and provides a high job satisfaction (Pollnac et al., 2001; Young et al., 2016). Indeed, many fishermen in the survey indicated that fishing was their preferred occupation or that it is a family legacy. They indicated not to be willing to leave the fisheries even if this would no longer be profitable. When asked what they would do if they had access to funds, many fishermen indicated they would invest in fishing or fish trade again. This unwillingness to quit declining fisheries has also been shown elsewhere. In Philippine fisheries, for example, half of the fishermen that were interviewed indicated they would stay in fisheries despite unprofitable catch-rates (Muallil et al., 2011).

Landing site officials

Many issues raised by landing site officials indicated non-adherence to fisheries regulation, such as fishing in closed areas and with illegal gear. Since it is part of the landing site officials' tasks to monitor these practices and to confiscate illegal gear, it is not surprising that these practices gained their attention. The issues they raised often coincided with the issues presented by fishermen, such as a lack of safety for fishermen because of the lack of safety gear, infrastructure on the beaches and dangerous weather conditions on the lake. Both groups also reported declining catch-rates and a lack of good fishing gear. Landing site officials indicated problems related to broader issues, like land use change, in contrast to fishermen, who mainly reported issues related to the lake, like safety issues and outdated gear.

The interviews were also intended as a platform for landing site officials to share ideas about possible optimisations to fisheries management. Some of the suggested solutions were aimed at policy makers, such as closure of the fishery, closure of spawning areas and stricter licensing. Some of the suggested solutions were related to awareness raising and educating the fishermen. Others, such as construction of infrastructure, could be carried out by the communities. The landing site officials, just like the fishermen asked for more enforcement of existing regulations. Both landing site officials and fishermen underlined the importance of alternative livelihoods for fishermen.

Conclusions and future research

The fisheries of Lake Tanganyika serve a critical role in food security in one of the poorest regions of the world. To preserve these valuable fisheries, adequate and effective management of the resource is indispensable. Knowledge of observations and opinions of fisheries stakeholders are needed to identify priorities and possible strategies for sustainable fisheries management. Through interviewing a wide array of stakeholders, we found that in general, most groups of stakeholders had similar opinions about the fisheries of Lake Tanganyika and the fisheries management. We showed perceived changes in fisheries resources, such as declines in catch-rates, reduced size of fish and increased prices on the markets. We gained insight into problems affecting fishermen in their professions, which are mainly health, safety and security concerns. We provided information on motivations for decision-making in fishermen, who chose their professions mainly because of a lack of other income, but also because they liked it, because of family legacy or because of good revenue.

The results offer suggestions for prioritising management efforts, as voiced by the community. Fishermen and landing site officials overall made the same suggestions for better fisheries management. An important call was made for safer working conditions, for example access to safety gear and hygiene services. Respondents agreed on the importance of better enforcement of existing legislation (gear, licensing and closing times) and access to better fishing gear and protection of the ecosystem of the lake. In our survey, most respondents agreed with the suggestion to close nursery areas from fishing activity. In order to do so, more research is needed to correctly identify these nursery areas. There was also consensus that fishing should not take place in the littoral zone. Besides potentially containing important nursery sites, the littoral zone also harbours a large part of the lake's ichtyobiodiversity (Van Steenberge et al., 2011). Hence, its protection will also have a positive effect on a wide range of fish species (Britton et al., 2017).

Because regular monitoring of the fisheries of Lake Tanganyika is difficult to organise, data is now scarce and fragmented. This study demonstrates that stakeholders can make useful observations about the ecosystem on limited temporal and spatial scales. Hence, besides consistent monitoring of not only limnological and biological factors (Plisnier et al., 2018), collecting the ideas, perceptions and opinions of stakeholders on a regular basis will be valuable for sustainable (fisheries) management of Lake Tanganyika. However, some lessons were learned in this survey that we advise to be taken into account in further studies. Foremost, as no temporal and spatial frame was mentioned in the questions, we do not know whether respondents answered questions based

on long- or short-term observations, or whether they refer to local or regional patterns. We recommend that future surveys would clearly distinguish spatial and temporal scales in the questions, related to age and experience of the respondents. Observations on catches should be recorded individually for different fishing techniques and gears, and collected per species. Besides the pelagic fisheries discussed in this paper, there are also important littoral fisheries in Lake Tanganyika. These fisheries are often carried out by women, children and fishermen who cannot afford a license, targeting littoral species or juveniles of pelagic species. Gears are often illegal and improvised, like mosquito nets. Enforcement of restriction of these fisheries without offering proper alternatives for these actors might have strong negative consequences in terms of food security and poverty reduction. Future studies are needed to assess opinions, observations and problems perceived by these fishermen as well.

Respondents acknowledge the need for better coordination of management between the four countries surrounding Lake Tanganyika. Since clupeid stocks are shared between the nations (De Keyzer et al., 2019; Kmentová et al., 2020), collaborative management between countries is needed. For successful lake-wide management to take place, it is necessary to have comprehensive knowledge of the opinions and preferred strategies of stakeholders around the entire lake. Future research needs to look into how much willingness there is for collaboration. To harmonise management advise, we suggest this type of study to be repeated in time and space along the shores of all riparian countries of Lake Tanganyika.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Author contributions

ELRDK, PMM, MPMV, JAMR, JH, FAMV and MVS conceived the study. All authors contributed to making the surveys. ELRDK, GAL, CAM, AAM, KA, PB, ABB, ABR, BHL, CH, JKB, SKS, HK, IKK, PLD, VLK, FL, JML, FSM, TMN, AMM, FMB, DMR, BM, KN, NNB, JPNK, JRW, RSR and OWN carried out the interviews. ELRDK, CETH, JAMR, LJMM and MVS analysed data. All authors contributed to writing the manuscript. ELRDK coordinated and finalised writing of the manuscript. LJdB, JH, PMM, FAMV, MPMV, JAMR, LJMM and MVS advised on contents editing, discussion and presentation of data.

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Appendix A. Supplementary data

Supplementary data is available via http://dx.doi.org/10.17632/4cnv66fcyy.1.

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