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1 **Local perceptions on the state of the fisheries and fisheries management in Uvira, Lake**
2 **Tanganyika, DR Congo.**

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66 **Abstract**

67 The fisheries of Lake Tanganyika play an important role in food security in Central and Eastern
68 Africa. Effective legislation, supported by local populations and resource users is needed to
69 support sustainable management of the valuable fish stocks. Knowledge of the perceptions
70 and an understanding of the concerns and struggles of stakeholders in the fisheries can
71 provide policy-makers with recommendations to adapt fisheries management. We
72 interviewed 1,019 stakeholders in one close-ended and three semi-open ended surveys.
73 Factor analysis revealed seven clusters of opinions. Linear-mixed effects models identified
74 common grounds and differences in opinions between groups of stakeholders about
75 strategies in fisheries management. Stakeholders of the fisheries spoke of challenges due to
76 weather or climate variability, a noticeable decrease in fish abundance and size, and increase
77 in price of fish on the market. Fishermen experienced a lack of safety on the lake, from
78 aggression and dangerous weather conditions, and hardly had access to safety gear and
79 infrastructure. Landing site officials, state employees who monitor the beaches, mentioned
80 capture of juveniles and declining catch-rates as the biggest threats to the fisheries. None of
81 the groups of stakeholders attributed the problems in the fisheries to overfishing or
82 overpopulation. We found similarities in opinions over a wide range of stakeholder groups,
83 with many stakeholders asking for better and fair enforcement of existing legislation. State
84 employees were more positive than the other groups towards creating more strict regulation
85 of the fisheries. The results presented offer focus-points for policy-makers to improve
86 management of the Lake Tanganyika fisheries.

87 Keywords: East-African Great Lakes, fisheries management, Lake Tanganyika, stakeholder
88 perceptions, surveys, sustainable fisheries

89 **Introduction**

90 The inland fisheries of Africa provide a crucial and often under-estimated source of food and
91 income for millions of people in some of the world's least developed regions (AUC-NEPAD,
92 2014; Fluet-chouinard et al., 2018). This certainly holds for the fishery in the world's oldest
93 and deepest tropical freshwater lake: Lake Tanganyika (East Africa, 03°20'-08°48'S/29°03'-
94 31°12'E) (Coulter, 1991; Lake Tanganyika Authority, 2012; Poll, 1953; Roest, 1992). This
95 ancient lake is well known for its unique biodiversity and its high levels of endemism
96 (Salzburger et al., 2014; Snoeks, 2000; Van Steenberge et al., 2011). It is shared by four
97 countries: the Democratic Republic of the Congo (DRC), Tanzania, Zambia and Burundi. Several
98 large population centres are found along its shores, including Bujumbura (Burundi), Uvira
99 (DRC), Kigoma (Tanzania), Kalemie (DRC) and Mpulungu (Zambia). In the last two decades, all
100 of these urban centres have increased in population at an annual rate of 3-4% (Ogutu-Ohwayo
101 and Balirwa, 2006).

102 The fisheries of Lake Tanganyika target multiple species with multiple types of gear (Lindley,
103 2000). The pelagic fisheries, the main focus of this paper, are centred around three species:
104 two endemic clupeids: the Lake Tanganyika sprat *Stolothrissa tanganyicae* Regan, 1917, and
105 the Lake Tanganyika sardine *Limnothrissa miodon* (Boulenger, 1906), and their main predator:
106 the sleek lates, *Lates stappersii* (Boulenger, 1914) (Mölsä et al., 2002). Additionally, the littoral
107 fishery targets juvenile *L. miodon* and demersal cichlid species (Petit and Shipton, 2012). In
108 the North of the lake, clupeid and *Lates* fisheries use so called 'apollos'. These apolloos consist
109 of two wooden boats, connected with wooden beams, and are manned by a team of four to
110 six fishermen. These teams of fishermen fish at night using a lift-net, and use a light source to
111 attract schools of pelagic fish. In the littoral fisheries, fishermen mostly use beach seines,
112 gillnets and hook and line (Petit and Shipton, 2012). These littoral fisheries are often carried
113 out by women and children, and operate unregulated gear.

114 Fisheries legislation of the DRC is regulated top-down, dates back to 1981 and has not been
115 revised since. In the Lake Tanganyika fisheries, all fishing activities need to be registered and
116 fishermen are required to pay a registration fee of USD 20 annually. The minimum allowed
117 mesh size for lift-nets is 4 mm, and it is illegal to discard fish catches. Industrial fishing, i.e.
118 fishing with units whose combined length of fishing nets exceeds 2,500 m, is forbidden within

119 5 km of the shoreline (Petit and Shipton, 2012). Each landing site has four landing site officials,
120 two of the department of fisheries, and two of the department of agriculture, who are
121 responsible for monitoring and enforcement of fisheries regulations. Compliance with
122 fisheries legislation is, however, low in the DRC. This is mainly due to a limited capacity for
123 enforcement and a lack of involvement of stakeholders in the formulation of legislation (AU-
124 IBAR, 2016). Common illegal practices include fishing from non-prohibited landing sites,
125 fishing without a license, fishing with mosquito nets, and fishing too close to the shore
126 (McLean et al., 2014; Petit and Shipton, 2012). Fishing with mosquito nets is the only means
127 of access to the fisheries resource for a part of the population (Bush et al., 2017; Short et al.,
128 2018), especially impoverished women (Short et al., 2020). However, this illegal gear targets
129 juvenile fish (Petit and Shipton, 2012), potentially contributing to food insecurity and
130 increased poverty (Jones and Unsworth, 2020). The illegal catch of juvenile *L. miodon* causes
131 an estimated economic loss of USD 2.1 million annually (Mulimbwa, Sarvala, & Micha, 2018).

132 At several sites, littoral fish habitats are being disturbed by the extraction of sand and gravel.
133 Runoff, caused by the clearing of land for agriculture, and the extraction of wood for fuel and
134 building materials, has further affected the littoral zones by increased sedimentation
135 (Nkotagu, 2008; Plisnier, Nshombo, Mgana, & Ntakimazi, 2018). Additionally, untreated
136 wastewater flows into the lake (Plisnier et al., 2018), depositing pollutants and causing
137 eutrophication (Nkotagu, 2008). Conversely, climate change has led to a warming of the upper
138 water layer and increased stratification (O'reilly 2005, Kraemer 2015), reducing productivity
139 and increasing transparency (Stenuite et al., 2007; Verburg et al., 2003). There are also reports
140 of decreased wind speeds, further increasing stratification (O'Reilly et al., 2003; Plisnier,
141 2000). All of the above changes can have negative effects on the fish stocks.

142 The territory of Uvira is situated at the northern end of the lake, and contains one of the lake's
143 largest population centers, the city of Uvira. Increased population pressure, increasing
144 demand for protein, and a lack of employment, led to an increased number of fishermen,
145 both legal and illegal, intensifying pressure on the fish stocks (Mulimbwa, 2006; Petit and
146 Shipton, 2012; Van der Knaap et al., 2014). There are reports of a decrease in catch-rates (the
147 catch by weight per effort spent fishing) at the northern end of the lake of the larger latid
148 species (van Zwieten et al., 2002) and the clupeid species (Mulimbwa, 2006; Sarvala et al.,
149 2006). These decreases may be linked to increased fishing pressure and changes in climatic

150 factors (Kolding and van Zwieten, 2012; O'Reilly et al., 2003). However, efforts to document
151 the total catch and catch per unit effort (CPUE) have been sporadic and inconsistent (Plisnier
152 et al., 2018), making assessment of catches and fisheries potential speculative (Kolding et al.,
153 2019).

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

170 Differences in types of interaction with the resource lead to differences in viewpoints between
171 groups of stakeholders, which will influence their support for specific management measures.
172 Fisheries scientists and policymakers tend to emphasise a direct link between management
173 measures and fish stocks. Fishermen on the other hand put more emphasis on the
174 unpredictability of nature, and less on the effect management measures have on fish stocks
175 (Verweij and van Densen, 2010). Fishermen will rely on information of a smaller time and
176 spatial-scale, being their own experience and that of colleagues and relatives, while scientists
177 and policymakers integrate information from larger time and spatial-scales, thus revealing
178 patterns at those scales that are masked by variability at smaller scales (van Densen, 2001).
179 To improve gender equity in decision making, knowledge of the opinions and practices of both
180 men and woman is valuable. Perspectives might differ (Barclay et al., 2017), if for example

181 regulations were formulated with mostly the interest of men in mind, men would be expected
182 to be more positive towards existing legislations. Fisheries practices mainly carried out by
183 women, like mosquito net fishing, might be overlooked and therefore not be included in the
184 legal framework (Kleiber et al., 2015). On the other hand these practices might therefore
185 remain under the radar of enforcement.

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

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

205

206 **Material and methods**

207 Data collection

208 Stakeholders of the fisheries were defined as those who are directly or indirectly influenced
209 by the pelagic fisheries in territory of Uvira, through fisheries related employment, or regular
210 consumption of fish. This implies that a large part of the inhabitants of Uvira were considered

211 as stakeholders. The interviewed stakeholders covered a wide range of interactions with the
212 resource, and encompassed different social and political positions (authority). We considered
213 three groups of stakeholders: a broad group of all stakeholders of the fisheries, including but
214 not restricted to fishermen and landing site officials, a separate second group of only
215 fishermen, and a third group of only landing site officials (Figure 1). The broad stakeholder
216 group was chosen to represent all those dependent on the fisheries. Additional interviews
217 were done with fishermen only, because of their large interest in and influence on the
218 resource. Fishermen were defined as people who have pelagic fishing as main source of
219 income. Landing site officials are employees of the state who monitor fisheries practices and
220 collect fisheries statistics on the different landing sites. Additional interviews were held with
221 these landing site officials because of their experience with the fisheries. To include all the
222 main markets and landing sites in the area, interviews were conducted at 25 locations in Uvira
223 (Figure 2, SM1). The study sites were chosen based on the expectation to find respondents,
224 and to achieve an optimal geographical spread to reduce various biases based on geography,
225 or location.

226
227 Four questionnaires were developed: one questionnaire with closed statements for all the
228 stakeholders of the fisheries, and three semi-open ended interviews, one for all the
229 stakeholders of the fisheries, one for fishermen specifically, and one specifically for landing
230 site officials (Table 1, SM2). Development of questionnaires was a participatory co-production
231 by researchers and officials connected to these fisheries, encompassing 25 scientists and
232 students, 4 officials and 6 NGO representatives. Together they decided on the content and
233 formulation of questions, selected which groups of stakeholders would be interviewed and
234 selected locations. In total, 32 interviewers interviewed stakeholders over a three-day period
235 in August 2018 and over a three-day period in October 2018. Each interview was conducted
236 and recorded by two or three interviewers and notes were compared to increase reliability of
237 recording. The interviews were constructed in French, and interviewers asked the questions
238 in French or Kiswahili.

239

240 Opinions of all stakeholders on management strategies

241 A close-ended survey, consisting of Likert scale (1 totally disagree – 5 totally agree) questions
242 about fisheries management and statements related to the ecosystem of Lake Tanganyika

243 (Table 2) was done with 562 stakeholders of the fisheries (187 female and 370 male).
244 Respondents represented all stakeholders of the fisheries as described above (broad
245 stakeholders group). Respondents were grouped into six categories according to the
246 profession they indicated: fishermen (n = 233), merchants (n = 130), state officials (n = 31),
247 education (teachers and students) (n = 42), agriculturalists (n = 64) and other (n = 61). For an
248 overview of professions included in each of the categories, see supplementary material (SM3).
249 We classified these groups in relation to the effect members can have on the fishery
250 (influence) and to the importance of fisheries in the lives of the respondents (interest) (Figure
251 1). The purpose of this survey and subject population was to assess opinions of stakeholders
252 on fisheries and lake related issues and possible management options, and to identify
253 differences and similarities in opinions between different groups of stakeholders.
254 Interviewees were chosen by addressing people on a successive encounter basis at landing
255 sites and at places where fish is bought and consumed, such as fish markets, hotels and
256 restaurants. Additional sampling was done in the same way at government offices and at
257 schools to address state employees, students and educators.

258

259 Semi-open ended questions for all stakeholders

260 A second questionnaire aimed at the same group as the previous questionnaire: i.e. all of the
261 stakeholders of the fisheries, consisting of semi-open ended questions, informed about
262 observed changes in the ecosystem, observed changes in the quality and availability of the
263 resource, and about the availability of fish as food source. There were 196 respondents, of
264 whom 91 were men and 104 women; grouped according to main profession, we interviewed:
265 38 fishermen, 66 merchants, 9 state officials, 3 teachers and students (education), 38
266 agriculturalists, and 42 other.

267

268 Semi-open ended questions for fishermen

269 A semi-open ended questionnaire with 229 fishermen was used to: identify motives for
270 choosing the profession of fishermen; identify their preferred management strategies; assess
271 the economic importance of the fisheries to the fishermen; and record their perceptions of
272 changes in the lake's ecosystem and fisheries output. All respondents were men.

273

274 Semi-open ended questions for landing site officials

275

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

289

290 Data analysis

291 For the closed statements, average Likert scores per question were calculated for the different
292 categories of stakeholders. To visualize how different professional groups differ in their
293 answers to the questionnaire, a biplot based on principal component analysis (PCA) was
294 constructed using the Factoextra package in R (Kassambara and Mundt, 2017). Separation of
295 professions on the PC axes was tested with ANOVA (stats package in R, R Core Team, 2018).
296 To identify differences between professions and sex, and interactions between sex and
297 profession on responses to the 26 statements, we used a linear mixed-effects model, following
298 the guidelines of Zuur and Ieno (2016), using the lme4 package in R (Bates et al., 2015). We
299 modelled the scores on the 26 questions as a function of sex and profession and the
300 interaction sex*profession. To eliminate the influence different interviewers had on the
301 results, we added interviewer as random variable. The response variable was coded on a 1-5
302 Likert scale. We used a model assuming Gaussian distribution. The best model was identified
303 using backwards selection, retaining the model with the lowest cAIC, using the stepAIC
304 function of the cAIC4 package in R (Saefken et al., 2018). Fixed effects (sex and profession)
305 were tested using type III Wald F-tests (Kodde and Palm, 1986). If the F-tests indicated

306 significant differences between the professional groups, multiple comparisons of means with
307 Tukey contrasts were used to find which pairs of professions differed significantly, corrected
308 for multiple testing with Benjamini-Hochberg p-value adjustment (Benjamini and Hochberg,
309 1995), using the multcomp package in R (Hothorn et al., 2008).

310

311 Factor analysis (FA) was used to group questions that were answered in a similar way. To find
312 the optimal number of factors, we used parallel analysis. This technique compared the
313 eigenvalues of the data to eigenvalues of simulated random data, and returned the lowest
314 number of factors for which eigenvalues were significantly greater than those obtained from
315 the simulated data (Horn, 1965). We used minimal residuals FA (Comrey, 1962), followed by
316 varimax rotation, an orthogonal rotation method that maximizes the variance of the loadings
317 for each question on the factors while keeping the factors uncorrelated (Kaiser, 1958). As a
318 quality check of the FA, we calculated the Tucker Lewis index, the root mean square residual
319 (RMSR) and the root mean square error of approximation (RMSEA). The Tucker Lewis index is
320 an estimation of the discrepancy between the final FA, and a simulated null model (Tucker
321 and Lewis, 1973). A Tucker Lewis index of 0.95 or above indicates a good fit. RMSR is the
322 average square root of the discrepancy between the sample covariance matrix and the FA
323 covariance matrix. Values for the RMSR range from 0 to 1, with a lower measure indicating a
324 better fit of the FA with the data. Values below 0.08 are considered to indicate a good fit (Hu
325 and Bentler, 1999). The root mean square error of approximation (RMSEA) is a comparable
326 measure, but with optimization of parameters. Here value below 0.06 indicate a good fit (Hu
327 and Bentler, 1999). These analyses were done using the psych package in R (Revelle, 2018).
328 Factors were interpreted by analyzing the statements in each factor, weighed by their
329 contribution to the factor. To find the contribution of profession and sex on scores on the
330 factors, we used a linear mixed-effects model with interviewer as random variable, in the
331 same way and with the same model selection process as discussed above. All analyses were
332 performed using R 3.5.2 software (R Core Team, 2018).

333 For the three open-ended questionnaires (Table 1), responses were coded into categories in
334 a three-step process, following the protocol outlined by Bryman (2008). First, each response
335 was coded into categories based on meaning. Responses that had the same meaning but were
336 differently phrased were treated as the same. In a second stage, answers were merged into
337 overarching categories. The number of times a response was given, and the percentage to the

338 total was calculated. In the last stage, answers were ranked according to occurrence, removing
339 all response categories that were less frequent than 3%. Analyses were performed in
340 Microsoft Excel.

341

342 **Results**

343 Opinions of stakeholders on management strategies

344 Average Likert score was calculated per question (Table 2, SM4). Overall, respondents agreed
345 most with the following statements: 'The government must teach better fishing methods to
346 the population' (Q19); 'Deforestation around the lake must stop' (Q03); and 'Scientists must
347 gather more information on fisheries' (Q07). Respondents disagreed more with: 'There are
348 too many fishermen, which leads to overfishing' (Q09); 'There is overpopulation, which leads
349 to overfishing' (Q10); and 'The fishery should be closed a few months per year' (Q01). There
350 was limited separation of the respondents on the first three PC axes (Figure 3), indicating a
351 high level of agreement between respondents on most of the statements. The first PC
352 correlated strongly to the 1-5 scale on the questionnaire. State officials, people in education
353 and the 'other' group scored higher on this axis (ANOVA, $F(5, 555) = 13.59$; $p < 0.01$), indicating
354 that in general, they agreed more with the statements than the other groups. The second axis
355 slightly separated fishermen from the other groups ($F(5, 555) = 11.95$; $p < 0.01$) (Figure 3A).
356 There is a slightly significant separation on PC3 ($F(5, 555) = 2.53$, $p = 0.03$) (Figure 3B). Based
357 on cAIC, for each question separately, each time the best was the model without the
358 interaction term: $\text{Response} \sim \text{Profession} + \text{Sex} + (1 | \text{Interviewer})$. Reports of the regression
359 parameters of the model and the anova on the model for each question can be found in SM5
360 and SM6 respectively. Linear-mixed effects models revealed significant differences between
361 professions and sexes on eight questions. Differences that were significantly different after F-
362 test (for sex, since we recorded only two levels for sex) or post-hoc Tukey contrasts (for
363 professions) are indicated in Table 2 and SM7. State officials and people in education agreed
364 more to the statements in the closed-ended questionnaire than fishermen and agriculturalists
365 . This difference was especially pronounced on the statements asking for more licensing and
366 more government control and for regulation of fishing gear (SM4, Table 2).

367

368 Parallel analysis grouped the questions into seven factors, together explaining 39% of the
369 variance in the data (Table 3, Figure 4). Tucker Lewis index of factoring reliability was 0.89,

370 which is below the optimally suggested value of 0.95, (Tucker and Lewis, 1973). The RMSR was
371 0.03 and RMSEA index was 0.043 (90% CI: 0.035-0.048), well below the maximally acceptable
372 values of 0.06 and 0.08 respectively (Hu and Bentler, 1999). Although the low Tucker Lewis
373 index might indicate a mismatch between the model and the data, it was still deemed
374 acceptable as the RMSR was below 0.06 (Hu and Bentler, 1999). Factor one explained 9% of
375 the variance in the data. It grouped the statements about limiting access to the fisheries, by
376 closure of parts of the lake for fishing and by limiting the number of gear a fisherman can
377 deploy. This factor also included statements asking for research to gather more information
378 on the fishery and about the potential alternative of aquaculture. The second factor (6% of
379 variance) combined statements about more action from the government by increasing
380 cooperation between the four riparian countries (Q16), exercising more control over the
381 fisheries (Q15) and teaching better fishing methods to the population (Q19). This factor also
382 included statements about providing more staff and money for control institutions (Q06), and
383 more involvement of local communities in resource management (Q11). The third factor (6%)
384 grouped statements about enforcement of existing legislation: regulations of fishing gear
385 (Q02), stricter measures against illegal fishing (Q05) and the catch of juvenile fish (Q14), and
386 enforcement of the closing period (Q01). Each of the other factors explained less than 5% of
387 the variance. The fourth factor was about too much fishing activity, and the fifth factor
388 highlighted the negative effects of environmental degradation. Factor six combined
389 statements about a lack of alternatives for fishermen and the last factor consisted of a singular
390 statement about safety for farmers.

391

392 After backwards model selection, retaining the model with lowest cAIC, the model that was
393 selected for each factor was the one with sex and profession as fixed effects, and interviewer
394 as random effect: Factor \sim Profession + Sex + (1| Interviewer). Significant differences were
395 found between different professions (Figure 4, SM10) and sexes in two of the factors (Table
396 3). Reports of the regression parameters of the model and the anova on the model for each
397 question can be found in SM8 and SM9 respectively. Men scored significantly more positive
398 than women on two factors: call for more action from the government (factor 2: ANOVA, $F(1,$
399 $529) = 8.17, p < 0.01$), and lack of alternatives (factor 6: $F(1, 530) = 12.5, p < 0.01$). There is a
400 trend ($p < 0.1$) of men scoring more positive on factor five, negative effect of environmental
401 degradation. State employees scored more positive than the other professions on the call for

402 more action from the government (factor 2: $F(5, 540) = 2.50, p = 0.03$). On factor one (limiting
403 fishing effort) there is a trend ($p < 0.1$) of fishermen scoring less positive than the other groups.
404 On factor three, enforcement of existing legislation, there is a trend towards state employees,
405 people in education and people in the other group scoring more positive than the other
406 groups.

407

408 Semi-open ended questions for all stakeholders

409 In a questionnaire aimed at all stakeholders of the fisheries, we asked the respondents
410 whether they had noticed any changes in the lake, or the fish. The most frequent answers
411 were linked to climate or weather effects (strong winds, more rain) and effects of
412 eutrophication (green color of the lake) (Table 4). Of the respondents, 23% said almost all
413 species of fish on the market were becoming smaller. It was reported that fish quality was
414 lower than before (Table 4). When asked if it had become more difficult to buy fish for the
415 family, compared to other food, 67% replied yes, 28% reported no differences and 9% replied
416 this fluctuated with the supply.

417

418 Semi-open ended questions for fishermen

419 Ages of respondents ranged from 18 to 78 with an average of 38.1 (sd +/- 13.3) and a median
420 of 35. Experience as a fisherman ranged from 0.5 to 52 years, with an average of 15.6 (sd +/-
421 11.5) and a median of 12. The majority of the fishermen (57%) indicated having an additional
422 livelihood to supplement income from fishing. Most respondents (72%) also had other family
423 members active in the fisheries. As a motivation for becoming fishermen, 69% of the
424 respondents reported a lack of a more profitable source of income (Figure 5A). The three main
425 problems reported by fishermen were theft of fishing gear and harassment by gangs (44%),
426 strong winds that caused dangerous waves (35%), and a decline in catch-rates (28%) (Table 5).
427 As proposed improvement to the fisheries, our respondents suggested receiving of or access
428 to better, modern and regulated fishing gear (45 %), better enforcement of the current
429 fisheries regulation (39%), and assured safety for fishermen on the lake (27%) (Table 6). We
430 also inquired about what limit of catch decline would be the turning point to leave fisheries.
431 Many fishermen (39%) replied that they would stop fishing when they would have no more
432 profit from the fisheries. Some fishermen (26%) replied they would only stop when they would
433 find different work or capital to finance a new profession. One out of five indicated they would

434 continue fishing no matter how low their catches would become (Figure 5B). When asked
435 what they would do after quitting the fisheries, 33% replied that they would do nothing, either
436 due to lack of alternatives or because of retirement. Agriculture was the most popular
437 alternative to fisheries (28%), followed by trade (19%) (Figure 5C). If our respondents would
438 receive money to invest in their next profession, most would use it to invest in (fish)trade (62
439 %) or fisheries (23%) (Figure 5D).

440

441 Semi-open ended questions for landing site officials

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

450

451 **Discussion**

452 Opinions of stakeholders on management strategies

453 After assessing the opinions of the various stakeholders of the fisheries in Lake Tanganyika,
454 stakeholders of different occupational groups showed similar opinions about management
455 strategies, despite different involvement and interest in the fisheries. Our expectation that
456 state officials would be more positive towards restrictive measures than fishermen, was
457 confirmed. State officials also scored higher on the factors combining statements about
458 strengthening government involvement in fisheries and increasing the enforcement of
459 existing legislation. Since the questionnaires were developed by fisheries scientists and state
460 officials, this might partially explain why these groups agree more with the statements. These
461 state officials might have faith in the current rules and regulations because they have been
462 taught these rules during training, and have – ideally- been trying to enforce these. This faith
463 in the current rules might partially explain why these groups agree more with statements that

464 are in line with existing legislation. The livelihoods of resource managers, contrary to those of
465 fishermen, are not directly affected by fisheries restrictions, which might also explain why the
466 former were less opposed to restrictions (McClanahan and Abunge, 2016). As predicted,
467 fishermen agreed less than other stakeholder groups that fishing effort should be limited, and
468 indicated more than other groups that not enough alternative livelihoods next to fishing were
469 available. None of the respondent groups agreed to the statements that overpopulation or
470 too many fishermen were causing overfishing. As expected, the factors where men scored
471 significantly higher than women were those most associated with enforcing existing rules and
472 regulations, such as gear restrictions and a ban on catching juvenile fish, and with more
473 government control. These statements relate to the littoral fisheries, often dominated by
474 women, which, if current legislation was enforced, would be eliminated. In the past legislation
475 has been based more on the experiences of men than those of women, and thus is better
476 adapted to the needs and perceptions of men.

477

478 Changes perceived by stakeholders

479 A semi-open ended survey assessed perceived changes to the lake ecosystem. We expected
480 that stakeholders would report changes in the lake ecosystem related to climate change.
481 Stakeholders indeed indicated changes in rainfall, and in the level and colour of the lake.
482 However, since these questionnaires were conducted at the start of the rainy season and after
483 an intense algal bloom (personal observation, August 2018; Ndayisenga, 2018), many
484 respondents might have been referring to recent changes. As the questionnaires did not
485 specify a time scale for the observations, it was difficult to disentangle responses related to
486 weather from those related to climate. It was surprising that respondents indicated more
487 turbidity since, as a consequence of climate change, productivity in Lake Tanganyika has
488 dropped, decreasing turbidity (Stenuite et al., 2007; Verburg et al., 2003). This is probably
489 caused by respondents referring to a local scale, corresponding to their day to day experience.
490 In Uvira, which is a densely populated area, eutrophication may have increased productivity,
491 locally increasing turbidity. A similar phenomenon of locally increased turbidity around
492 populated areas has been observed in Lake Victoria (Hecky et al., 2010). The effects of
493 eutrophication would, however, be limited to the littoral, since cold runoff water would sink
494 below the thermocline in deeper waters (Plisnier, 2000). In our survey, fishermen and other

495 stakeholders indicated an increase in wind, contrary to temporal recordings, which showed
496 no indication of any change in wind speed (Verburg and Hecky, 2009) or only a slight decrease
497 (O'Reilly et al., 2003; Plisnier, 2000). Since these studies are more than a decade old, more
498 recent data on wind speeds is needed. Possibly, respondents in our interviews who reported
499 an increase in wind speeds witnessed these in the past months, as wind speeds are higher
500 during the dry season (May-September) (Plisnier et al., 1999). Regular surveys with fisheries
501 stakeholders can be used to better document this type of climate-variability.. Collecting this
502 data on larger time scales, and combining it with other measurements, will give a clear image
503 of changes on local and regional scales, on different time scales, and its effects on the fisheries.

504

505 Stakeholders indicated that fish on the market were becoming smaller and that larger species
506 were becoming rare (Table 4). They also reported that fish had become more difficult to afford
507 compared to other food items. This observation corresponds to the observations made by
508 fishermen, who indicated decreasing catch-rates, as discussed below. Since monitoring of
509 Lake Tanganyika fisheries has been scant and fragmented (Kolding et al., 2019; Plisnier et al.,
510 2018), and the government's enforcement capacities are limited, future management will
511 benefit greatly of stakeholder involvement, to acquire information for stock assessment, and
512 to increase consensus on issues related to resource use.

513

514 Fishermen's concerns

515 Fishermen reported as their main problem that fishing gear was often stolen and that they
516 were often harassed by armed gangs. They reported a lack of safety gear such as life jackets,
517 combined with dangerous weather conditions, such as high winds that cause waves. In many
518 African artisanal fisheries, bad weather conditions are one of the leading causes of accidents
519 for fishermen (Remolà and Gudmundsson, 2018). Due to a lack of weather warning systems
520 in and around Uvira, fishermen are on the lake even under suboptimal weather conditions.
521 Implementing an early warning system, such as in Lake Victoria, where a model predicts
522 thunderstorms based on satellite data (Thiery et al., 2016), can potentially save many lives. In
523 addition, fishermen reported attacks by crocodiles and hippopotami. Fishermen do not have
524 radio communication, decreasing the chance of rescue after an incident (Ben-Yami, 2000).

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

529 As the third most often mentioned issue, about a quarter of the fishermen indicated a decline
530 in catch-rate as one of their biggest concerns. Our survey shows that 72% of fishermen
531 interviewed had multiple members of their families employed in fisheries. A declining catch-
532 rate could have a serious negative impact on the incomes of these families, which are heavily
533 dependent on fisheries, since alternative employment is scarce. Previous research showed
534 perceptions of fishermen to be reliable indicators of changes in catch-rates (Rochet et al.,
535 2008), although these perceptions are dependent on individual catch variability (van
536 Oostenbrugge et al., 2002). Seasonal fluctuations might have caused temporarily reduced
537 catch-rates, while the general trend remained steady (Kolding and van Zwieten, 2012; van
538 Zwieten et al., 2002). The low season in the North of Lake Tanganyika falls between March
539 and June (Kimirei and Mgaya, 2007). Since interviews took place in August and October, when
540 catches are expected to be high, it is unlikely that stakeholders were reporting seasonal
541 declines in catch-rate and resource availability. Despite reporting declining catch-rates,
542 fishermen in our survey did not report that there was overfishing or overpopulation.
543 Fishermen tend to see the fisheries as an unlimited resource. They do not attribute changes
544 in catches to an increase in fishing effort, but to outdated gear, and to a switch to less bright
545 lights to attract the fish. Note that recent research however, showed that the new LED lights
546 were more efficient, so should lead to an increase in catch-rates (Mgana et al., 2019). The
547 discrepancy between this finding and the experience of the fishermen merits to be examined.
548 We would expect fishermen to be in favour of management practices that are in line with the
549 perception they have of fish abundance. Indeed, in our survey fishermen do not support more
550 strict catch restrictions, corresponding to their viewpoint that there is no overfishing, so there
551 is no use for further restricting catches. They did show a large willingness to participate in
552 existing fisheries management and asked for better and fair enforcement of existing fishing
553 legislation, especially to eliminate the unfair competition from fishermen that operate
554 illegally. Fishermen wished for a reliable governance system that protects them against
555 aggressors, illicit taxes, harassment and theft, and fair enforcement of legislation.

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

565

566 Landing site officials

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

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

584

585 Conclusions and future research

586 The fisheries of Lake Tanganyika serve a critical role in food security in one of the poorest
587 regions of the world. To preserve these valuable fisheries, adequate and effective
588 management of the resource is indispensable. Knowledge of observations and opinions of
589 fisheries stakeholders are needed to identify priorities and possible strategies for sustainable
590 fisheries management. Through interviewing a wide array of stakeholders, we found that in
591 general, most groups of stakeholders had similar opinions about the fisheries of Lake
592 Tanganyika and the fisheries management. We showed perceived changes in fisheries
593 resources, such as declines in catch-rates, reduced size of fish and increased prices on the
594 markets. We gained insight into problems affecting fishermen in their professions, which are
595 mainly health, safety and security concerns. We provided information on motivations for
596 decision-making in fishermen, who chose their professions mainly because of a lack of other
597 income, but also because they liked it, because of family legacy or because of good revenue
598

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

611 Since regular monitoring of the fisheries of Lake Tanganyika is difficult to organise, data is now
612 scarce and fragmented. This study demonstrated that stakeholders can make useful
613 observations about the ecosystem on limited temporal and spatial scales. Hence, besides
614 consistent monitoring of not only limnological and biological factors (Plisnier et al., 2018),
615 collecting the ideas, perceptions and opinions of stakeholders on a regular basis will be
616 valuable for sustainable (fisheries) management of Lake Tanganyika. However, some lessons

617 were learned in this survey that we advise to be taken into account in further studies.
618 Foremost, as no temporal and spatial frame was mentioned in the questions, we do not know
619 whether respondents answered questions based on long- or short-term observations, or
620 whether they refer to local or regional patterns. We recommend that future surveys would
621 clearly distinguish spatial and temporal scales in the questions, related to age and experience
622 of the respondents. Observations on catches should be recorded individually for different
623 fishing techniques and gears, and collected per species. Besides the pelagic fisheries discussed
624 in this paper, there are also important littoral fisheries in Lake Tanganyika. These fisheries are
625 often carried out by women, children and fishermen who cannot afford a license, targeting
626 littoral species or juveniles of pelagic species. Gears are often illegal and improvised, like
627 mosquito nets. Enforcement of restriction of these fisheries without offering proper
628 alternatives for these actors might have strong negative consequences in terms of food
629 security and poverty reduction. Future studies are needed to assess opinions, observations
630 and perceived problems by these fishermen as well.

631

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

640

641 **Abbreviations**

642 ANOVA – analysis of variance

643 AU-IBAR – African Union – inter-African bureau for animal resources

644 AUC-NEPAD – African Union commission - New partnership for Africa’s development

645 CPUE – catch per unit of effort

646 DRC – Democratic Republic of the Congo
647 PC - principal component
648 PCA – principal component analysis
649 LTA – Lake Tanganyika Authority
650 MANOVA - multiple analysis of variance
651 RMSEA - root mean square error of approximation
652 RMSR - root mean square of the residuals

653

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659

660 **Author contributions**

661 ELRDK, PMM, MPMV, JAMR, JH, FAMV and MVS conceived the study. All authors
662 contributed to making the surveys. ELRDK, GA, CMAM AMA, KA, PB, ABB, ARB, HB, CH, JKB,
663 SSK, HK, KKI, PLD, FL, JML, FMS, NM, AMM, FMB, DMR, NNB, JPNK, JRW, RRS and OW carried
664 out the interviews. ELRDK, CETH, JAMR, LJM and MVS analysed data. All authors contributed
665 to writing the manuscript. ELRDK coordinated and finalised writing of the manuscript. LjdB,
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676

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952 number of times this response was given, % = percentage of this response in total group.
953 Respondents were allowed to give multiple answers.

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955 n = total number of times a response was given, a = number of times a response was given
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957 given by someone from the fisheries department (n = 17).

958

959

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972 categories range from 1 (disagree) to 5 (agree) on a Likert scale. Symbols indicate the six
973 groups: agriculturists, fishermen, merchants, education, state officials and other.

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983 are indicated in bold.

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985 and P-values for the fixed effects of the Linear-mixed effects models on the 7 factors. The
986 estimated value for the random effect (σ Interviewer) is indicated.

987 SM 9: Results from Linear-mixed effects models that tested for fixed effects of sex and
988 profession, and the random effect of interviewer for the scores on the 26 statements.
989 Significant effects (Type III tests, $P < 0.05$) are indicated in bold. Df = Degrees of freedom. Df
990 res = degrees of freedom of the residuals.

991 SM 10: Results of Linear-mixed effects models post-hoc comparisons between professions
992 for the scores on the factors. There were no significant results.

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

Respondents	Type of questionnaire	Type of questions	n
All stakeholders	Close-ended	26 statements about management options	562
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 problems for Lake Tanganyika fisheries	32

996

997 *Table 2: Close-ended questionnaire with stakeholders of the fisheries: average score and 95% confidence interval per question for the different*
 998 *professional categories. n = number of answers given. Significant differences ($p < 0.05$) in responses between sexes and groups of stakeholders,*
 999 *tested with type III Wald F statistics, and post-hoc Tuckey contrasts for professions, after a linear mixed-effects model eliminating the effect of*
 1000 *different interviewers are indicated. Stakeholders are grouped into six categories: agriculturists (a), fishermen (f), merchants (m), education (e),*
 1001 *state employees (s) and other (o). Sexes are male (M) and female (F).*

1002

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	

1003

1004 *Table 3: Factor analysis of the close-ended questionnaire with stakeholders of the fisheries:*
 1005 *grouping of questions into seven factors and loadings for each question on their respective*
 1006 *factor. Difference = the significant differences for these factors between professions and sex,*
 1007 *tested with type III Wald F statistics, and post-hoc Tuckey contrasts for professions, on a*
 1008 *linear mixed-effects model with interviewer as random effect and profession or sex as test*
 1009 *variables. Professions are grouped into six categories: agriculturists (a), fishermen (f),*
 1010 *merchants (m), education (e), state employees (s) and other (o). Sexes are (M) male and (F)*
 1011 *female.*

1012

Factor	Questions and loadings on the factor		Differences	
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	
	Q06	Control institutions should receive more staff and more money	0.5	F < M
	Q19	The government must teach better fishing methods to the population	0.5	aefmo < s
	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	F < M
	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	
	Q21	If there was easy access to practical education, people would have more alternatives for fishing	0.7	F < M
	Q23	There is too much fish on the market that comes from outside the territory of Uvira	-	
	Q24	If it were safer to farm, it would be a good alternative for fishing	0.3	
	Q24	If it were safer to farm, it would be a good alternative for fishing	0.6	

**Factor seven:
safety for
farmers
(3%)**

1013

1014 *Table 4: Semi-open ended questionnaire with stakeholders of the fisheries: number of*
1015 *respondents is 195. n = number of times this response was given, % = percentage of this*
1016 *response in the total group. Respondents were allowed to give multiple answers.*

1017

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
Did you notice changes in the fish (size, quality, taste, presence of worms)? In which fish?	Lower lake level	5	3
	No differences	54	28
	Almost all fish smaller	44	23
	All fish lower quality (rot fast)	23	12
	Mikeke (adult <i>L. stappersii</i>) smaller	27	14
	Lumbu (adult <i>L. miodon</i>) smaller	11	6
	Change in taste for fish caught with a gillnet	11	6
	Less kuhe (<i>Boulengerochromis microlepis</i>) sold at market	7	4
	Change in taste mikeke	6	3
	Karumba (adult <i>S. tanganycae</i>) smaller	5	3
Ndagala* or nyaminyamu (Juvenile <i>L. stappersii</i>) smaller	9	5	
Kungura (<i>Limnotilapia dardennii</i>) tastes rotten	5	3	

1018 * Ndagala is a mix of adult *L. miodon* and *S. tanganycae*, and juvenile *L. stappersii*.

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1020 *Table 5: Semi-open ended questionnaire with fishermen: number of respondents is 158. n =*
 1021 *number of times this response was given, % = percentage of this response in total group.*
 1022 *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	

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1025 *Table 6: Semi-open ended questions with landing site officials: number of respondents = 38. n*
 1026 *= total number of times a response was given, a = number of times a response was given by*
 1027 *someone from the agriculture department (n = 21), f = number of times a response was given*
 1028 *by someone from the fisheries department (n = 17).*
 1029

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
	What needs to be done for better fisheries in Lake Tanganyika?	Extraction of sand and stones	
Cutting of vegetation (like macrophytes), which destroys spawning areas			1
Lates are close to extinction			1
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	

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