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The tragedy of the inland lakes

Ben Sonneveld
Amsterdam Centre for World Food Studies/Athena Institute, Vrije Universiteit Amsterdam, Netherlands
b.g.j.s.sonneveld@vu.nl

Frejus Thoto
Centre d'Actions pour l'Environnement et le Développement Durable, Abomey-Calavi, Benin
f.thoto@aced-benin.org

Donald Houessou
Centre d'Actions pour l'Environnement et le Développement Durable, Abomey-Calavi, Benin
d.houessou@aced-benin.org

Lia van Wesenbeeck
Amsterdam Centre for World Food Studies/School of Business and Economics, Vrije Universiteit Amsterdam, Netherlands
c.f.a.van.wesenbeeck@vu.nl

Abstract: Increased pressure on communal fishing grounds is testing the traditional regulations among fishing communities who should preserve inland waters' productive capacity and ecological values. Inland lakes in Benin are a typical case in point. With the mounting number of fisherfolk and pollution from densely populated urban areas the threat of overfishing and water degradation looms large. This paper questions whether customary rules of fishing communities can cope with current and future challenges. A survey among 839 fisherfolk found that agreements to control shared waters are virtually absent and remain unmonitored while mistrust and loss of faith in community members and government institutions result in low levels of organization. It is alarming to note the high incidence of conflicts that end violently, the prevailing food insecurity and a high illiteracy rate limiting employment to low-paid wage labour. Solutions to identified constraints go beyond the individual, requiring collective action and a platform where fishing communities can take matters into their own hands to avert a tragedy of the inland waters.

Keywords: Benin, conflicts, fisheries, inland waters, regulations

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1. The tragedy of the inland lakes

This section starts with a global overview of the problems identified in the inland fishery sector and then focuses on the situation in Benin.

1.1. The global picture

Fishing-related activities on inland waters constitute an important source of income for small-scale fisher families. Globally, inland fishery grew from an annual catch of 39 million tons in 1960 to 60 million tons in 2015 (FAO Accessed 1 January 2018a). In 2012 inland fishery was responsible for 30% of the global catch with an estimated value of 9 billion USD (World Bank 2012). Inland fishery also makes up an important part of the social fabric, employing 19 million fishers and 39 million people in post-harvest jobs worldwide. A vast majority (97%) of inland fishers live in developing countries (ibid.) where the sector provides nutritious food and a safety net for poor households.

There is, however, growing evidence of widespread overfishing of inland waters (Allan et al. 2005; FAO 2012), an observation that is underpinned by local evidence in, for example, Nigeria (Olopade et al. 2017), the Amazon (Castro and McGrath 2001), Vietnam (Cosslett and Cosslett 2018), Lake Victoria (Aura et al. 2018), China (Maa et al. 2018) and the USA (Zorn 2017). The effects of overfishing are not only economically apparent in the form of declining catches but are also catastrophic because of the loss of species and diversity (Allan et al. 2005). Though attention to overfishing has been more focused on marine resources, Kirk Winemiller, stated '… fish from inland waters are more threatened than those in oceans' (National Geographic News 2015). Calls for action are, therefore, justified but designing the correct and appropriate policy interventions is not easy.

The reason is that inland waters represent large and indivisible ecosystems whose regeneration processes are complex and comprise many interactions among multiple stakeholders (Keyzer et al. 2009). Although it may seem that these characteristics are shared by the wider marine systems, an important difference is the number of stakeholders and intensity of interaction between them. Drawing on Hardin's seminal example of communal rangelands (Hardin 1968), inland waters are considered open-access resources that are difficult to protect from unpaid use and can be overexploited in a relatively short time period. Hence, this excludability problem could lead to a 'Tragedy of the Inland Lakes' where uncontrolled fishery activities overexploit fish stocks, moving away from a sustainable economic and ecological equilibrium. As argued in Keyzer et al. (2009), assigning property

rights to internalize externalities for overexploitation (the market-based solution to overexploitation of the commons) is not possible for large areas whose open-access character is vital for the functioning of the (eco)system. For inland waters, this is clearly the case, as regeneration processes of inland lakes operate at the lake level. Hence collective action and regulation are required to avert the tragedy.

Lessons learned from landbased resource-excludability issues can help in formulating appropriate policy responses, particularly to avoid destruction of essential productive properties of the area through the assignment of individual property rights. For this case, agreed sets of judicious rules among users of common property resources have been developed (such as by nomadic pastoralists, see, for example, Sonneveld et al. 2017). The impact of regulatory principles for commonly shared resources depends on decentralized decision-making processes, a monitoring scheme to evaluate the quality of the resource base and a lasting commitment of custodians, with schemes to reward good guardianship and penalize neglect. Compared to land-based ecosystems, inland lakes are characterized by the additional complexities associated with the fact that that migrating fish are largely invisible. Hence, in traditional fishing techniques it is difficult to agree on regulation and monitoring (Berkes 1985; Mamun and Brook 2015) as participants incur high transaction costs in agreeing on objectives, information collection, implementation, enforcement of management (Willmann 1999) and distribution of costs and benefits (Scott 1993). The management of shared water resources involves regulations to ensure myriad objectives including sustaining the fish production and conserving the water areas. Three forms of regulations regimes can be identified: traditional, formal or government-led, and co-management. In Ghana for example, the fisheries management system involves important structures such as the Community Based Fisheries Management Committee and the Chief Fisherman who oversees the resolution of conflicts and regulates access to fishing at the community level (Nunoo et al. 2015). Various measures that form traditional regulations of fishing activities include: non-fishing days (one per week) during which it is not allowed to fish, and fishers can use those days to maintain gear and equipment, resolve conflict, rest and carry out other social activities; ban on landing certain fish species during festival periods to prevent overfishing; taboos and cultural practices focused on the water areas during certain periods of the year to help manage the fish stocks (Nunoo et al. 2015). In Malawi, fisher communities also set traditional rules and regulations for fisheries. An example is that in villages where beach seines are operated, there is a local historical understanding and agreement that regulate who can operate their nets, where and when; and sometimes in the form of rotation among fishers (Nunan et al. 2015). Traditional regulations also provide for sanctions to fishers who contravene the prevailing regulations. In many fishery-based communities in Cambodia, for example, there are graded sanctions – if someone violates the law for the first time, s/he is given advice about the negative effects of such practices; a second offence leads to a fine and possibly confiscation or destruction of the gear used (Kurien et al. 2016).

Governments also intervene in fisheries regulations mostly in the form of Fisheries Act and Regulations. For example, there is an Act and Regulations to ensure effective management of fisheries resources and protection of Lake Victoria's environment. The law stipulates several measures that include: prohibition on using destructive gear and methods like beach seines, gillnets with a mesh size less than 12 mm, dagaa nets with mesh sizes less than 10 mm; water splashing and other harmful fishing practices like the use of poison, trolling, weirs and diving (Mahatane et al. 2017, 220). Fishers who violate the regulations face fines or jail or both. Similar government-led regulations exist in Ghana and Benin.

There is evidence that regulatory rules are beneficial for inland water management when the decision-making process on formal and informal allocation on fishing areas and quantitative fishing rights is decentralized (limited property rights, Berkes 1985). Olomola (1993) and Nathan and Ahmed (Accessed 2017) found for inland waters in Nigeria and Bangladesh, respectively, that regimes of common property management in traditional inland fishing communities are more effective than privatization or public control. These findings are also in line with the Nobel Laureate Elinor Ostrom (Ostrom et al. 1994), who showed that collective community action can convert common property resources into an epitome of sustainability. Conversely, failing institutions that weaken management of the commons can seriously threaten their long-term use and might generate conflicts that wreak havoc upon the communities involved (Dietz et al. 2003). However, both traditional and formal regulations implemented in isolation have proven ineffective in preventing the decline of fish stock and the protection of the water areas (Wilson et al. 2003; Mahatane et al. 2017). Therefore, co-management has been adopted as a solution to ensure enforcement of both traditional and formal regulations. Sen and Raakjr Nielsen (1996, 406) defined co-management as 'an arrangement where responsibility for resource management is shared between the government and user groups'. In East African countries, co-management promoted the formation of community-based structures known as Beach Management Units (BMUs) with which all people engaged in fish-related activities should register (Nunan et al. 2015; Tweddle et al. 2015). In addition to BMUs, Co-management Committees are established with the participation of Fisheries officers to achieve the combination of local and government forces in managing the fisheries.

Be that as it may, inland fishery management is currently poorly documented and largely underresearched, which makes it difficult to formulate the correct policy interventions. Many complex inland water issues remain unresolved (FAO 2016).

1.2. The case of Benin

Benin is a typical case in point. In the period 1960–2013 the inland fishery sector produced annually on average 27,000 tons,[1] employing 57,500 fishers and 40,000 women active in fish processing and marketing (FCWC Accessed 2017). The

[1] The fishery sector active in marine waters captures between 10,000 and 16,000 tons per year.

sector provides additional employment for 300,000 people in related work, such as logging for acadja's (traditional infrastructure for capturing fish), construction of canoes, fish processing and storing. The demand for fish exceeds supply and Benin imports fish to the value of 61 million USD and exports the equivalent of 0.2 million USD (FAO 2017). A time-series analysis over the period 1960–2015 shows a decline in total catch from 24,504 tons per year (average of 1960–1970) to 20,630 tons (average over 2005–2010) (FAO accessed 2018b) while the number of fishers rose from 10,000 in 1950 to 62,000 in 2016 (compiled from: Buffe 1958; Welcomme 1972; Dioury 1983; Turay and Verstralen 1997; FAO 2007; Anon 2010; Ahouandjogbe et al. 2013; Belhabib and Pauly 2015). Combining catch and number of fishers reveals a worrying declining trend in both total catch and catch per person (Figure 1).

The catch per fisher fell from 1.1 to 0.3–0.4 ton while the total catch declined from 28,000 (period 1960–1980) to 24,000 tons fish per year (period 1980–2000) to 22,000 tons fish per year (period 2000–2015). Since demand for fish still largely surpasses supply, fishers could easily sell bigger yields, meaning that the declining catch per fisher points to an overfishing of the lakes.

This argument is strengthened by the fact that fishing-based households are also overrepresented in the poorest segment of the wealth index (INSAE and ICF 2013) with 36% compared to urban (10%) and rural population (26%). For other wealth classes the percentage of fishing-based families equates those of rural households. We can conclude that poverty is widespread among fishing-based families (Figure 2).

Concerning the regulations for managing the inland waters of Benin there is a clear historical angle on the functioning of the local institutions involved. In pre-colonial times, self-regulation among fishing communities was well structured,

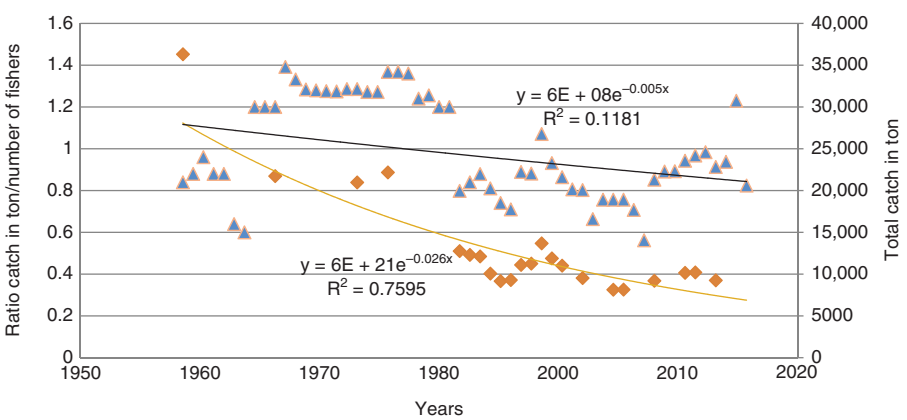

Figure 1: Catch of fish in ton per fishermen (brown diamonds) and total catch (blue triangles) for inland waters of Benin over the period 1960–2015. Equations of smoothed regression lines are shown with r square statistics. (Sources: FAO Accessed 2018b; Belhabib and Pauly 2015).

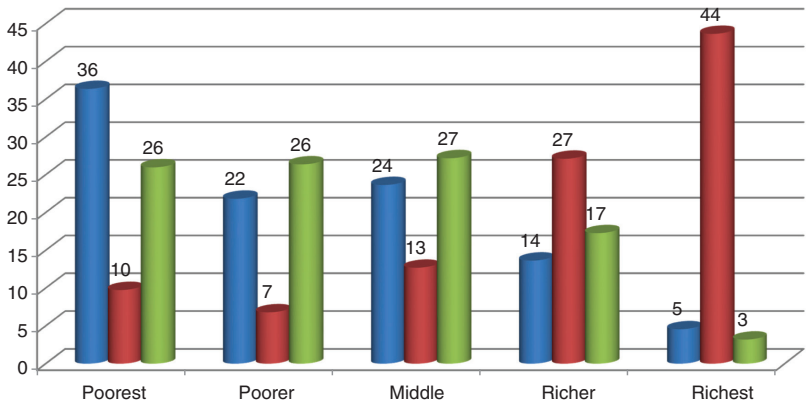

Figure 2: Share of fisher (blue), rural (green) and urban (red) population by wealth.

organized through respected social lines and reflecting a deep, religiously motivated, respect for cultural heritage and natural endowments. These institutions were undermined under French occupation, when new legislation on the use of land and water resources was introduced and different responsibilities were assigned to local leaders (Dangbégnon 2000). After the colonial period there were various efforts to recover and improve the inland lake institutions, some with a continuation of traditional religious regulations (Briones et al. 2016). Many institutions failed, however, some because important stakeholders, such as the government, were absent, others because of conflicting interests between groups of fishers using different fishing techniques (Dangbégnon 2000). It is not yet clear whether local regulations and customary rules among the fishing-based communities are effective and if they are resilient enough to cope with new challenges including population pressure, climate change, urban pollution and contested claims on fishing grounds. Though the biophysical environment of inland waters in Benin has received attention in recent years (Villanueva et al. 2006; Lalèyè et al. 2007; Lalèyè and Entsua-Mensah 2009; Gnohossou et al. 2013) and forms a solid empirical base for further research, there has not so far been large-scale research on fishers' institutions, which also hinder the formulation of appropriate policy interventions.

This study aims to analyze the current functioning of local institutions and assess their capacity to address future challenges. The project interviewed 839 fishers who are active in Lake Nokoué and the Lagoon of Porto Novo. The survey elicits information on household characteristics, food security, activities, fishing techniques (Figure 3), regulations to share water resources and constraints on development. In the conclusions we compare the management regulations for shared fishing waters for inland lakes of Benin with Elinor Ostrom's eight prerequisites for sustainable and equitable development of common pool resources. A focus group discussion (FGD) was organized to corroborate the survey findings.

Figure 3: Harvesting an acadja.

The article is organized as follows. Section 2 presents the sampling framework, survey design, instructions for surveyors and processing of collected information. Section 3 reports on findings of the survey by subject: general information and rules, ownership, rules on sharing water resources and constraints. Section 4 synthesizes the findings and concludes.

2. Data and methods

This section describes the implementation of the survey, the geographical distribution of the respondents, the sampling method, design of the survey and processing of the data.

2.1. Sampling

Aggregation of individual information on location of fishers and FGDs with local fishery agencies revealed the existence of 75 fishing-based communities, comprising 20,868 fishermen and 5665 women active in the fishery sector across four municipalities (So-Ava, Cotonou, Porto-Novo, and Aguégués) corresponding to eight cities (Cotonou, Vekky, Ganvié, Houedome, Porto-Novo, Dekanmey, So-Ava and Zoungame). In total a random sample of 802 fishers was planned for these eight cities; none was excluded. For each city the share of fishers from total fishing population of all eight cities was calculated. This share was applied to the total sample size to determine the number of surveyed fishers from each city. Next, households were drawn from each segment at random with replacement. The first household of each segment was selected for the interview. If this

Table 1: Number of respondents by city.

City	Frequency	Percentage	Cumulative frequency	Cumulative percentage
Cotonou	182	23.95	182	23.95
Dekanmey	38	5.00	220	28.95
Ganvie	132	17.37	352	46.32
Houedome	112	14.74	464	61.05
Porto-Novo	85	11.18	549	72.24
So-Ava	24	3.16	573	75.39
Vekky	143	18.82	716	94.21
Zoungame	44	5.79	760	100.00

household was not available it was replaced by the second, etc., until one was found that was willing to participate in the interview. To ensure that no community was missed at least two fishers from each income segment[2] (small, middle and large-scale, six in total) were interviewed for each community, increasing the total number of fishers interviewed to 839.

Concerning the various ethnic groups that participate in fishery activities, officials from the Ministry of Agriculture [Ahouandjogbe (2017) personal communication] and counterparts from ACED [Thoto (2017) personal communication] indicated that ethnicity did not play a major role in distinguishing and characterizing inland fishery activities. Ethnic neutrality on fishery activities in the study area was also confirmed by Atti-Mama (1998), who could not relate survey results of Lake Nokoue to the four identified ethnic groups (Ouemenou, Goun, Toffin and Hxla). Hence, ethnicity was not included as a stratification parameter nor was it included in the questionnaire.

2.2. Geographical distribution

Concerning the geographical distribution of respondents, Table 1 presents these by city. About 24% reside in Cotonou, 19% in Vekky while Ganvie, Houedome and Porto-Novo report 17%, 15% and 11%, respectively. Dekanmey, So-Ava and Zoungame report less than 10%. For 79 respondents the locality was not well documented or could not be marked.

Figure 4 shows that survey locations and frequencies. Locations are fairly divided over Lake Nokoué and Lagoon of Porto Novo.

2.3. Survey instructions

Interviewers were given detailed survey instructions for testing the questionnaire, using both the paper and the digital version. Furthermore, sampling schemes for fishery-based populations were discussed as well as strategies to build trust with

[2] A knowledge brief produced by Houessou et al. (2016) categorizes the fisher communities in three income segments locally named big fishermen, middle fishermen, and small fishermen.

Figure 4: Mapping survey frequencies.

fishers and how to deal with controversial answers. A storyline was written to introduce the purpose of the survey and to indicate how the collected answers would be used to propose future policy measures to be discussed with a broad group of stakeholders with the fishers' active participation.

2.4. Survey design

The survey was designed in a spreadsheet format with validated lists in scroll-down menus as standard responses, and fields for open answers. To facilitate import into SAS for further processing, the responses were automatically stored in a separate sheet with question coding in the first row and answers in the second row.

2.5. Processing

The survey was processed in SAS. Collated output was read as a vector from Excel sheets and labelled according to question codes. Categorical answers[3] were harmonized in standard formats and presented as frequencies. Numerical answers were processed and presented as mean or percentiles. Some data were presented in cross tables to elucidate bilateral relationships. The data are

[3] Categorical answers refer to qualitative responses on e.g. a certain quality interpretation (bad, moderate, good), quantitative data grouped in intervals (0–1 m, 1–2 m, ..) or dichotomous answers (yes/no).

organized such that they can be easily extracted, combined and prepared for further analysis.

2.6. Validation

A FGD with fisher community leaders (11), fisherwomen (4), and local agencies of the Ministry of Agriculture (4) was organized to corroborate the main findings of the study on: food security, enterpreneurship, water-sharing rules and lack of self-organization. Selected stakeholders were presented for the first time with survey results. Biased responses were avoided as there was neither time nor space to formulate a strategic response (e.g. Meeuwig et al. 2005).

3. Results and discussion

Results are presented over four categories[4]: general (3.1), fishing (3.2), rules on sharing water resources (3.3) and constraints and mitigation (3.4).

3.1. General

In this section we present the characteristics of the respondents concerning education, housing, other employment and food security.

3.1.1. Education

A total of 79% of the respondents indicated that they had never attended school and could not read nor write. That is much higher than the national average for adult men (55%; World Bank Accessed 2018a). Illiteracy among women is even higher (93%; 78% national average).

3.1.2. Housing

More than 90% of the fishers owned a house, but only 32% reported having electricity and less than 3% had to a refrigerator. On average houses have three rooms with percentiles indicating that 20% of respondents have a maximum of two rooms or less, 50% a maximum of three and 75% at most four rooms. We conclude that ownership of houses is high, electricity is largely absent while a refrigerator and, most likely, other electric devices are lacking. The housing conditions confirm the rather poor environment of fishing communities and the restrictions on working at night. The absence of electricity also increases the use of open fires for cooking and light, with associated hazards for health and safety.

[4] The report Sonneveld et al. (2018) 'What does the fisherman want', Amsterdam Centre for World Food Studies, Vrije Univesiteit and the Centre d'Actions pour l'Environnement et le Développement Durable, Abomey-Calavi, Benin, provides a full documentation of survey results.

Table 2: Days spent on other working activities.

	Frequency	Percentage	Cumulative frequency	Cumulative percentage
How many days per month do you practice this other work activities?				
Na*	2	0.56	2	0.56
0–10	80	22.60	82	23.16
10–20	66	18.64	148	41.81
20–30	206	58.19	354	100.00

*Not applicable.

3.1.3. Other activities

Among respondents, 42% (477 persons) had also other employment. Those working in other sectors were active in farming (15%), and other work like livestock farming and commercial activities (65%). Of the 477 persons with side activities, 206 were able to indicate the time spent on other activities than fishing (Table 2). This group indicated that 58% spent more than 20 days per month on other work, while 23% and 19% spent a maximum of 10–20 days per month, respectively, outside the fishery activities. We observe that 78% spent more than 10 days per month on other activities. We can conclude that an important share of fishers has side jobs that occupy a considerable amount of time.

3.1.4. Food security

An important indicator of the welfare and health of the population are food security conditions and continuous access to sufficient, safe and healthy food. In our case we tested food security by asking fishermen if they experienced one or more days during a month when there was no meal, one meal or two meals only. Table 3 shows the results by city. In total an alarming 32% experienced a situation of there being no (5%) or only a single meal (28%) during at least one day per month. Column percentages show that the share with no or a single meal is highest in Porto Novo (12% and 64%, respectively). There is a large middle group of Cotonou, Ganvie, Houedome, So-Ava, Vekky and Zoungame where 30–35% of

Table 3: Cross frequency for percentage of respondents by number of meals per day by city.

	No meal	Single meal a day	Single meal or more per day	Total
Cotonou	2.24	4.74	16.97	23.95
Dekanmey	0	0.13	4.87	5
Ganvie	1.05	5	11.32	17.37
Houedome	0	4.74	10	14.74
Porto-Novo	1.32	5.13	4.74	11.18
So-Ava	0	0.92	2.24	3.16
Vekky	0.39	5.53	12.89	18.82
Zoungame	0	1.97	3.82	5.79
Total	5	28.16	66.84	100

Table 4: Number of responses for time share (per cent) per fishery system.

Share	Acadja	Medokpokonou	Crab	Line fishing
0–<25	13	14	42	40
25–<50	33	37	42	37
50–<75	30	44	11	21
75–<100	25	6	6	3

the fishing populations had no or a single meal per day. Only Dekanmey shows a low percentage (5%). The findings on food security confirm the high incidence of fishers in the lowest group of the wealth index.

3.2. Fishing

This section characterizes fishing activities concerning ownership, time spent on fishing techniques, the catch and average earnings.

3.2.1. Ownership

Approximately 70% of the fishermen indicated that they owned an acadja,[5] 13% owned a medokpokonou[6] while 9% owned both an acadja and a medokpokonou, while 27% had neither. The 8% of respondents who owned crab baskets and 17% practising line fishing also owned acadjas (50% and 62%, respectively) and medokpokonous (7% and 9%, respectively). Only 3% of the respondents practised fish farming.

3.2.2. Time spent

Table 4 shows the share of time fishers spent on various production systems. Most time is spent on the acadja and medokpokonou. The latter is especially labour-intensive due to its multiple harvests per year. The acadja also requires time for maintenance.

3.2.3. Acadja

As the acadja is the most prominent fishing technique practised in the study area we characterize its management in greater depth than other fishing systems. Fishermen who worked with acadjas were also the sole owner (96%). On average one acadja was owned, with a 70 percentile border of two. A majority (68%) had owned the acadja for 10 years or more (Table 5).

Respondents indicated that 50% inherited the acadja from his father, 33% constructed the acadja himself and 14% purchased one. The price of an acadja is related to its size, location (distance to household, markets), density of poles and

[5] An acadja encloses an area in the lake by wooden poles to create a safe habitat and breeding ground for fish.

[6] A medokpokonou uses fine-mesh nets to trap fish.

Table 5: Period of ownership (in years) of the Acadja.

	Frequency	Percentage	Cumulative frequency	Cumulative percentage
For how long (in years) are you the owner of the acadja?				
0–5	71	12.33	71	12.33
6–10	113	19.62	184	31.94
11–15	101	17.53	285	49.48
16–20	98	17.01	383	66.49
21–25	44	7.64	427	74.13
26–30	76	13.19	503	87.33
>30	73	12.67	576	100.00

Table 6: Price of an acadja in CFA.

	Frequency	Percentage	Cumulative frequency	Cumulative percentage
1–250,000	31	46.97	31	46.97
250,001–500,000	22	33.33	53	80.30
500,001–750,000	6	9.09	59	89.39
750,001–1,000,000	7	10.61	66	100.00

accessibility. For a general impression, we give a distribution of prevailing prices (Table 6). The maximum price was 250,000 CFA[7] (381 €) for 47% of the respondents, to more than 500,000 CFA (762 €) for 20%. With a GDP per capita of 1714 € (World Bank, World Development indicators, 2017) this means that an acadja equates 22–44% of an annual income. None of the respondents leased or rented out his acadja. Concerning its size, 14% own an acadja of less than 0.25 ha, 31% less than 0.5 ha, 27% between 0.5 and 1 ha, while 42% have an acadja larger than 1 ha.

3.2.4. Harvests: acadja

The frequency of harvests of an acadja is predominantly once a year (54%), 21% harvest once every two years and 16% every three years. Approximately 3% harvest multiple times per year. The average yearly catch per acadja is 2635 kg, about 33% of the respondents catch less than 500 kg, 18% between 500 kg and 1500 kg and more than 46% catch more than 3000 kg. In CFA the average yearly catch is 2,650,829 (4041 €), 40% earn less than 1,500,000 CFA (2287 €) and 40% earn more than 2,500,000 (3811 €). On average 10 persons assist in harvesting acadjas, and 75% receive an average wage of 41,670 CFA (63 €).

3.2.4.1. Earnings

To get an idea of the fishers' earnings we take average figures from the previous paragraph and assume that harvesting an acadja lasts three days, using 10-man

[7] CFA, Communauté Financière Africaine (African Financial Community). One CFA is 0.00152449 € (10/8/2017).

assistance each receiving 40,000 CFA as daily wage. We calculate the average annual net income per acadja as:

Value catch	2,650,829 CFA
Labour costs (10 man * 3 days * 40,000 CFA)	1,250,100 CFA
Depreciation poles	60,000 CFA
Net income	1,390,829 CFA

The 1,390,829 CFA or 2120 € divided over, say, five family members would be 424 €, much lower than the GDP per capita of 732 € reported as national average in the World Development Indicators (World Bank Data accessed 2018b). It is clear that fishers require other fishery activities or other jobs to support their families; living from acadja-related fishery activities alone will be difficult.

3.2.5. Harvests: medokpokonou

A medokpokonou is harvested multiple times per year; 54% of the respondents indicated harvesting less than 200 times per year. Using the 50th and 75th percentile of the data (the mean is here not very informative as it is determined largely by a few outliers) we observe that catch has the value of 8500 and 16,750 CFA, respectively. Using the value of the 50th percentile and for 200 catches per year, the harvested annual value would be 1,700,000 CFA (2591 €), roughly 20% more than earned by harvesting acadjas. Maintenance costs are considered negligible.

3.2.6. Harvests: crab fishing

We observe that for crab fishing the frequency and mean value of the catch varies largely, making it difficult to make a meaningful assessment for income generated by crab fishers. Taking the average frequency and value of 50th percentile we would get an annual income of 395,000 CFA (602 €), which clearly indicates that crab fishing is a secondary activity, next to a main income-generating activity.

3.3. Rules for sharing water resources

This section reports on the information collected on the sharing of water resources in Lake Nokoué and the Lagoon of Porto Novo. It presents information on restrictions for locations, distance requirements of other fishermen, conflicts, trust and organizations.

3.3.1. Restrictions

Respondents (81%) indicate that the location of acadjas is restricted and cannot be constructed anywhere (Table 7). The selection of locations is more relaxed for production systems that are less intervening and have a less permanent structure like medokpokonou, crab and line fishing according to 67–88% of the fishermen. Locations for fish farming are also restricted.

To the question *'Why are you not allowed to develop fishery activities in other areas?'* a 40% referred to community-level agreements (Table 8), 19% had agreements at the individual level. A limited number had agreements with government

Table 7: Can you develop your fishery activities anywhere on the lake?

	Acadja	Medokpokonou	Crab fishing	Line fishing	Fish farming
No	81	33	24	12	80
Yes	19	67	76	88	20

Table 8: Agreements with various institutions on fishery developments.

	Frequency	Percentage	Cumulative frequency	Cumulative percentage
Why are you not allowed to develop fishery activities in other areas?				
Agreements with other communities	227	40.32	227	40.32
Agreements with individual fisherman	107	19.01	334	59.33
Agreements with government	4	0.71	338	60.04
Agreements with local authorities	41	7.28	379	67.32
Other (specify)	184	32.68	563	100.00

Table 9: Percentage share of fishers requiring distance to fish production system.

Distance in meter	Acadja (n=792)	Medokpokonou (n=834)	Crab fishing (n=838)	Line fishing (n=836)
No distance	60	85	90	84
0–<5	27	9	8	12
5–<10	10	0	1	2
10–<15	2	1	1	1
15–<25	1	3	0	0
>25	0	0	0	0

authorities (8%). Concerning the category 'others' (32%), 13% referred to arrangements that were at the level of the community, 15% mentioned that private property had to be respected.

To the question 'What happens when you develop fishery activities in forbidden areas?', 11% answered that they would get a fine or be subject to public shame. A different answer as categorized was given by 66%, and of those a 5% indicated that their acadja would be destroyed and 10% wanted to warn the local police.

Table 9 shows that 60% of the fishermen had no requirements on putting other fishermen at a distance from their acadja system. A 40% indicated a certain distance; 27% 0–5 m, only 13% wanted a distance of more than 5 m. The majority did not require any distance from nearby fishermen to their medokpokonou production system (86%), crab fishing (90%) and line fishing (84%). Hence, we conclude that most fishermen believe that the presence of individuals near their production systems does not influence the catch. There is no clear explanation for these counterintuitive responses; one would expect that distance would be respected since it increases chances of a better catch and reduces the incidence of conflict.

To the question 'What would happen if people from the own community are fishing near your area?', 78% answered that nothing would happen. In 13% of the cases people would talk to each other, 6% would tell the others to move and 2% would warn the community leader.

3.3.1.1. Conflicts

An alarming 34% indicated that there were conflicts over the use of water resources with members of their own community (Table 10), and 12% of the respondents indicated that there had been a conflict in the course of last year. In 50% of the conflicts there was a violent encounter where people needed medical attention or were killed. We note that this percentage is much higher than the national average 11% reported in Afrobarometer (Afrobarometer Data accessed 2018) who answered that they had been physically attacked at least once. Fishermen responded that in 87% of the cases the conflict was settled while 7% reported that it was under mediation. In 52% of the cases the local community leader mediated, while elders (13%) and local authorities (13%) were also involved. The high incidence of community-level conflicts raises question of the existence of a social fabric within the community, as it seems that there is no joint perception of belonging to the same social entity.

The same series of questions on conflicts was repeated but now for the case of conflict with members of another community. If people from another community were fishing nearby, 68% indicated that this was no problem and 20% would have a talk with the person. Respondents would ask the person to leave in 8% of the cases. While 35% of the respondents had a conflict with persons from another community, 50% of these ended in a violent encounter where people needed medical aid or were killed; 78% were settled; and 15% still under mediation. Community leaders (58%) and local authorities (22%) were leading the mediation process.

3.3.1.2. Trust

A share of 81% of the fishermen trusted their own family more than their fellow community members, 10% trusted their own family moderately more than community members and only 7% answered that the level of trust was the same for community members. A share of 89% answered that they trusted their own community members much (62%) or moderately (26%) more than members of another

Table 10: Conflicts over water resources; members of own community.

	Frequency	Percentage	Cumulative frequency	Cumulative percentage
Are there conflicts with the members of your community about the use of water resources?				
No	547	65.59	547	65.59
Yes	287	34.41	834	100.00

community; for 11% there was no difference in trust between the two groups. In line with the high incidence of conflict among community members (previous paragraph) we find an absence of trust that might clearly constrain the social care and bonding needed to create a responsible society.

3.3.1.3. Organization

Most of the fishermen, 65%, conduct their activities alone and are not dependent on others. Of the 17% that indicated that they went fishing in a group, 74% indicated that the group had an informal setting, 4% belonged to a cooperative or participated in another group.

A share of 63% of the respondents indicated that they did not belong to any organization. This percentage corresponds with the national average 65% found in the Afrobarometer, (Afrobarometer Data accessed 2018) who indicated that they did not belong to any voluntary association or community group. The 37% of fishermen who belonged to an organization were members of informal groups (54%), groups affiliated to the community (35%) or cooperatives (8%); 3% belonged to another kind of organization (Table 11).

Four out of five the members of a group were satisfied with the functioning of the organization and with the way in which it represented their interests and 16% were moderately satisfied. The small share that was not satisfied gave as reason that there was no leadership (45%) and there was no membership consultation (18%) (see also Table 12).

The reasons for not belonging to an organization were: 'existing groups did not function well' (32%), 'there are no groups' (35%), 'I can do it myself' (15%) or other reasons (17%). Obviously, there is a lack of coherence among the fishermen

Table 11: Kind of organization.

	Frequency	Percentage	Cumulative frequency	Cumulative percentage
What kind of organization is this?				
Community	111	35.13	111	35.13
Cooperative	26	8.23	137	43.35
Informal group	171	54.11	308	97.47
Others (specify)	8	2.53	316	100.00

Table 12: Organization: reasons for non-membership.

	Frequency	Percentage	Cumulative frequency	Cumulative percentage
Why do you not belong to an organization?				
Existing groups do not function well	165	31.73	165	31.73
There are no groups	184	35.38	349	67.12
I can do it myself	78	15.00	427	82.12
Others (specify)	93	17.88	520	100.00

to organize themselves. Groups are not recognized and the initiative to organize a lobby or interest group is largely absent. The low reported participation rate and participation in informal groups confirms this hypothesis.

3.4. Constraints

Fishermen were asked about the constraints that presented a threat for their production system. The constraints that were discussed are: water pollution, overfishing, theft, markets, conflicts, AIDS and access to credit. Below we report on the findings.

3.4.1. Water pollution

For 64% water quality was a constraint for their fishery activities. Urban areas were the main polluters (53%), motorboats contributed 7%. Grouping the category 'others' (40%) we get results presented in Table 13. For 20% flow problems caused pollution; the water was not refreshed enough. Low water quality, indicated by 23%; water was either too soft (11%) or too salty (10%). Flooding was mentioned in 11% of the answers, pollution by water hyacinth 14% and degraded acadjas in 4%. The findings confirm the constraints identified by Yehouenou et al. (2014), Degnon and Dahouenon-Ahoussi (2015) and recently Vodougnon et al. (2018), who found elevated ecological stress levels of Chemical Oxygen Demand, Biological Oxygen Demand and high concentrations of heavy metals, in Lake Nokoué and the Porto Novo lagoon.

A large majority of the fishermen (78%) did not believe that local authorities would help in solving the problem of water pollution. This is substantially higher than the national average of 47% of the Afrobarometer (Afrobarometer Data accessed 2018) who indicated that local politicians are 'not' or only a 'little bit' trusted. The city of Cotonou (69%) was, according to the fishermen, the main polluter, followed by Porto Novo (17%). Dumping of market waste (32%), household waste (26%) and the release of water by sewage systems (11%) were indicated as major sources of urban pollution. The category 'Others' was small (<1%).

Table 13: Other causes of pollution.

Other causes	Frequency	Percentage
Acadja degraded	8	4
Closure	31	14
Flood	25	11
Flow problem	45	20
Hyacinth	32	14
Other	30	14
Salt	21	10
Water low quality	4	2
Soft	25	11

Table 14: Constraints: overfishing.

	Frequency	Percentage	Cumulative frequency	Cumulative percentage
Do you consider overfishing as a constraint for your fishery activities?				
Yes	646	77.27	646	77.27
No	190	22.73	836	100.00

3.4.2. Overfishing

For 77% of the fishermen, overfishing was perceived as a constraint for their activities (Table 14). Overfishing was done deliberately (51%) and due to ignorance (11%), referring to mentality of the fishermen, and due to lack of control/supervision (16%), referring to absence of an authority that could control fishing activities. Yet, 88% indicated that control mechanisms were not a feasible option. Professor Laleye, a renowned expert on aquatic ecology, confirmed in a personal communication the overfishing on the lakes (Laleye 2018).

3.4.3. Theft and robbery

A share of 64% of the respondents indicate that theft and robbery were a constraint. Canoes (14%), nets (38%) fish (35%) were the main items that were stolen. Only in 23% of the cases was the thief caught, usually by the victim himself (60%), sometimes by members of the community (40%) but seldom by the police (1%). In 43% of the cases the robbery caused a conflict with other communities, which was settled in 81% of the cases either through mediation (76%) or compensation (4%).

3.4.4. Markets

Markets were considered a constraint for 29% of the respondents. The main reason was the distance (43%) and low prices in general (22%) particularly during the fishing season (22%). Unreliable relationships with brokers and traders were only mentioned by 5% of the respondents (Table 15). Markets would function better if there were more competition (26%) and if the access to urban markets (14%) or outside the lakes (14%) could be improved. Government authorities should take the lead in market reforms according to 50% of the respondents, followed

Table 15: Main reason for disfunctioning of markets.

	Frequency	Percentage	Cumulative frequency	Cumulative percentage
What is the main reason?				
Others	22	9.13	22	9.13
Distance	104	43.15	126	52.28
Low prices in general	52	21.58	178	73.86
Low prices during fishing season	52	21.58	230	95.44
Unreliable relation with brokers	2	0.83	232	96.27
Unreliable relation with traders	9	3.73	241	100.00

Table 16: Improvement of relationship with other communities.

	Frequency	Percentage	Cumulative frequency	Cumulative percentage
How do you think that the relationship with other communities could be improved most efficiently?				
Negotiations	38	34.55	38	34.55
Trade	2	1.82	40	36.36
Better agreements on use of water	67	60.91	107	97.27
Others (specify)	3	2.73	110	100.00

by community councils (31%) and local authorities (19%). Fishermen see no role for themselves or fishermen's organizations to improve the market system. This might be a conscious choice to leave the supervision of a proper functioning of markets to government institutions that have the required neutral and independent authority to control and penalize violation of rules.

3.4.5. Other communities

Only 13% of the respondents indicated that the relationship with other communities formed a constraint. Hence, the nature of the conflicts seem to occur at the individual level and not between the individual and communities or between communities. Focusing on this, the relationship with neighbouring communities was mentioned by 85%. Better agreements (61%) on water use and negotiations (35%) were indicated as best measures to improve relationships (Table 16). Again community (58%), government (35%) and local authorities (5%) should take the lead in improving the relationship with other communities.

3.4.6. AIDS and other diseases

AIDS was considered a constraint by 21% of the respondents. Extension (84%) was indicated as the best way to stop the spread of AIDS, followed by free distribution of condoms (13%), while 73% indicated that the government was not doing enough to spread AIDS in fishing communities. Malaria (95%) and diarrhoea (65%) were also considered major physical constraints on fishing activities.

3.4.7. Access to credit

A large share of the respondents (95%) said that access to credit is a constraint for their fishery activities (Table 17); 98% indicated that they would get a loan if they

Table 17: Constraints: access to credits.

D7__	Frequency	Percentage	Cumulative frequency	Cumulative percentage
Do you consider access to credit to be a constraint for your fishery activities?				
Yes	794	94.64	794	94.64
No	45	5.36	839	100.00

had access to credit, although 55% of the respondents were able to obtain a loan, from family (31%), a bank (15%) or others (53%). Under the category 'others', we find microfinance institutions like the 'institut de microfinance' (26%), 'Caisse Locale de Credit Agricole Mutuelle' (19%), 'Association pour la solidarité des marchés du Bénin' (8%), government programmes which provide credit to populations (18%), and the Tontine Group whereby participants contribute equally to a prize that is awarded entirely to one participant (5%). Most of the loans are used for buying wood for the acadja (60%), purchasing a boat (16%) or boat repair (7%). The acadja (38%), boat (18%) and house (17%) are the main collaterals.

4. Conclusions and recommendations

Despite serious overfishing of the inland lakes of Benin our survey results show that there are hardly any agreements among fishermen on fishing arrangements to further prevent their overexploitation. There are some restrictions on constructing acadjas but it is not clear if these rules are monitored and maintained.

The stress of overfishing might be correlated to the alarmingly high number of conflicts (34%) between members of their own and other communities, half of these ending up violently such that people needed medical attention or were killed. This is for us a clear indication that common property resource management is not functioning well. Comparing Elinor Ostrom's eight prerequisites for sustainable and equitable development of common pool resources with the current situation in the inland lakes of Benin (Table 18), we see that these conditions are only partly met. In the focus group, fishermen agree that there are some government regulations but these are not applied because of lack of monitoring and enforcement.

Declining catches affect the food security of about a third of the fishermen, with highest percentages in Porto Novo. Many (58%) seek compensation for income loss by working outside the sector but are limited by a high illiteracy rate (93%) to low-paid jobs. The FGD indicated that food security is especially

Table 18: Comparing Ostrom rules for CPR with Benin inland fishery situation.

Ostrom rules	Fishery system
1. Define clear group boundaries.	Not present
2. Match rules governing use of common goods to local needs and conditions.	Present
3. Ensure that those affected by the rules can participate in modifying the rules	Present
4. Make sure the rule-making rights of community members are respected by outside authorities.	Not present
5. Develop a system, carried out by community members, for monitoring members' behavior.	Not present
6. Use graduated sanctions for rule violators.	Not present
7. Provide accessible, low-cost means for dispute resolution.	Present
8. Build responsibility for governing the common resource in nested tiers from the lowest level up to the entire interconnected system.	Not present

difficult during a period of seven to nine months when fish traps are installed and traditional techniques are not efficient because fish hide deep under elevated water levels.

On the positive side, our survey shows that fishermen are clear entrepreneurs who invest in their own techniques and tools. Acadja owners know how to organize the labour for harvesting and all fishermen have good channels to markets. Despite their illiteracy, most know how to approach banks or micro-financing institutes and 55% succeed in obtaining a loan, though the focus group warned about informal loans from family or pawnbrokers with unfavourable reimbursement conditions.

With 63% of the respondents indicating that they do not belong to an association, while another 20% belongs to informal groups, we conclude that the degree of organization among fishermen is low. This can partly be attributed to historical interventions during the French colonial period, but in the current situation we refer to three reasons for the low degree of organization, all substantiated by the survey findings and confirmed during discussions with the national fishermen's association. First, mistrust among community members, illustrated by the high share (91%) that trusted their own family more than members of the community, the high incidence of violent conflicts, and the relatively high incidence of robberies and thefts. Overall, this provides little foundation for constructive collaboration.

The second reason is the loss of faith in government institutions, witnessed by the high share (78%) of respondents with no confidence that the government would solve pollution problems, the low government participation concerning agreements on sharing water (8%) and solving conflicts (13%). Nonetheless, there is a clear recognition by fishermen that government interventions are needed because the identified constraints (water pollution, markets, overfishing, AIDS and other diseases) require interventions that go beyond individual control.

The third reason is the sparse contacts between the executive board of the national federation of fishermen and its members. Discussions with the executive board revealed that there is a lack of resources to meet with the fishermen on a regular basis. Consequently, fishermen do not feel represented by their own association. Yet, the association occupies powerful positions in high-level government committees where it can influence decisions and solve problems that are identified in the survey. Hence, in theory, fishermen's associations seem well positioned in the government structure but are lacking a well-established platform where fishermen can express their needs in a timely manner, are actively involved in the formulation of policies and receive regular feedback from the association concerning their proposals.

4.1. A road map for interventions in the inland lakes of Benin; an inter- and transdisciplinary approach

A road map for policy interventions in the inland lakes of Benin should revitalize a productive stakeholder engagement that balances interests of fishers against the sustainable long-term development of fishing grounds. Solutions for these

conflicting objectives should not be sought in a mono-disciplinary approach because this oversimplifies prevailing complexities of the inland lakes as ecosystem. Policy interventions should acknowledge the goals and strategies of the actors involved and base their decisions on the findings of joint research drawing on multiple academic disciplines (inter-disciplinary), ranging from aquatic ecology to organizational management, which combines scientific knowledge with local experience (transdisciplinary).

This asks for a joint stakeholder platform that is (1) representative for the fishermen involved, (2) operational at the level of inland lakes, (3) uses capacities – technical, material and financial – to implement mechanisms for concerted actions, (4) ensures regular and timely feedback to the fishing community, (5) involves buy-out schemes to compensate fishers for stopping their activities, as necessary. In this perspective it is recommended that the government release resources and facilitate this transdisciplinary process by re-establishing such a platform to formalize and facilitate the contacts between the fishermen's association and its members.

Concretely, the stakeholder platforms should give high priority to the following issues to restore and create a sustainable and socially enviable environment. First, alternative employment programmes should persuade fishermen to find work outside the fishery sector. Declining catches and overfishing observed by fishermen and experts reveal that currently too many fisherman are active. For example, the data underlying Figure 1 show that if the current average level of 0.2 tons per fisherman has to be raised to 0.6 tons, about 40% should give up fishing. Experts and experienced fishermen should also indicate sustainable strategies that prevent overfishing and restore the fish stock. Second, the platforms should create conflict-resolution measures to avoid a trying and lawless environment in which people fear for their work and livelihood. The small number of cases where forms of conflict mediation/resolution were reported in the survey might be examples for further upscaling. Alternatively, fishermen could visit other areas where successful institutions serve as a standard for locally adjusted adoption. Third, stop the pollution. Concerning the pollution problem, the platforms should benefit from the multi-stakeholder environment in which fishermen, local authorities, and transporters jointly should seek sustainable solutions. This might include costly alternatives like the improvement of sewage infrastructure that go beyond the implementation capacity of individual fishermen or even communities. Therefore, it is recommended to include national and international organizations that could give financial and technical support to larger projects. The main points of change that are raised above will benefit from the design of dedicated tools that accurately represent the geography and dynamics of inland kakes. These tools support these decision-making processes by allowing a comparison of various prospective scenarios. The impact of policies should be illustrated in colourful maps and synoptic tables that are easily interpreted by a larger public and create a platform for inclusiveness as opposed to competition among the goals forwarded by the interest groups.

Clearly we are aware that the road map will demand the sustained engagement of the stakeholders involved, but the long-lasting effects of joint and intelligently designed sustainable interventions will greatly outweigh options based on ignorance and a short-term vision.

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