

## Article

# Namibian Experiences Establishing Community Fish Reserves

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**Abstract:** Inland fisheries play a critical role in the ecology of the Okavango Delta, but their conservation is particularly complex. For nearly a decade, communities, conservancies, policy makers, and partner organisations have worked to establish fish reserves across the Kavango and Zambezi. Guidelines on the establishment of fish reserves have been developed to delineate the process through which these protected areas are established, and a structured learning process has unpacked knowledge held by different stakeholders to better understand the opportunities and limitations of fish reserves and to subsequently revise these guidelines. This article aims to share these lessons and to contribute to the debate on the most effective institutional arrangements for this unique space of conservation.

**Keywords:** fish reserve; Okavango; land management; community participation



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## 1. Introduction

The Okavango River Basin is one of the largest freshwater systems in southern Africa [1], and fishing makes an important contribution to the livelihoods of riverine communities in the three countries of Namibia, Botswana, and Angola. However, poorly governed open access fisheries, and particularly, the use of monofilament gillnets and dragnets and the commercialization of fish has resulted in a decline in important high-value fish species such as redbreast, Threespot and Greenhead tilapias, and Nembwe and Tigerfish. This decline has been exacerbated by two other factors: the invasion of exotic species (e.g., the highly competitive Nile tilapia) and climate change, causing local fish species to be under severe stress and a risk of total ecosystem collapse. In addition to the ecological problem, there are livelihoods implications, given that riverine communities once had a readily available source of protein that is now under threat.

Namibia is a global leader in community-based conservation, but current approaches are based on decades of evolution and learning among actors intervening in the areas of policy, ecology, and community development [2,3]. There are many unresolved debates about the strengths and weaknesses of the different parts of Namibia's natural resource management approaches [4], but many contextual factors make Namibia a particularly innovative place for institutional arrangements that support sustainable conservation [5,6]. This includes the tourism industry, which made up nearly a third of the national economy prior to the pandemic, and approximately 40% of the country's land is under some kind of legal protection [7].

Inland fisheries are a natural resource that face several unique conservation challenges in Namibia. The shifting flood patterns across the Okavango Delta mean that the physical geography of this resource is constantly changing. As one of the driest countries in the world, Namibia's water resources are inherently under pressure. While inland fisheries are critical for household food security and provide some level of small-scale income in some

places, they have more limited prospects for larger scale commercialization [8]. Finally, the ecological and geographic differences in Namibia's river systems mean that one unified policy approach alone is challenging [9]. Some waterways form part of international borders, requiring further harmonization efforts to support conservation.

Despite all of these complexities, Namibia has championed community fish reserves and piloted a model that has demonstrated emergent conservation results in two regions. This article will explore the structured learning process that has taken place around the establishment of fish reserves in Namibia and will consider the lessons for policy development and implementation, community-based management, and conservation. These experiences demonstrate that Namibia's fish reserve model holds significant promise for rehabilitating the ecology of riverine systems in the Delta. However, there are certain preconditions for success that are based on localised dynamics. As such, an adaptive model that will simultaneously allow for community management systems to respond to local ecological and livelihood demands and that will provide holistic process guidance that can support scaling at a national level at the same time is required.

### *Background*

Since 2001, the Namibia Nature Foundation has worked with the University of Namibia, the Namibian Ministry of Fisheries and Marine Resources, and numerous other partners to support local communities in establishing fishery reserves. These are water bodies that have been identified by local communities and for which community-defined use restrictions are put in place that aim to restore and conserve fish stocks. The rules are enforced by community fish guards and range from no-fishing to traditional-gear-only fishing. The rules are tailored to local needs, provided that they are ecologically meaningful, socially acceptable, and within the Namibian legislation framework. Fishery reserves are co-managed and legally recognized by the government, and offenders are prosecuted by the Traditional Authorities and the Government.

There are currently over 20 community-managed reserves that are legally recognized, which cover a total area of approximately 2500 hectares [pers. Comment R Burger 2021] and include smaller pools, backwater channels, and mainstream stretches of river. The success is multilayered: fish quantities increase, fish are larger, and there is more diversity in the fish species available. The recovering fish stocks spill over into the wider river system, and the positive impact is evident in the fishers' catches [10]. Fish play an important role in the fight against malnutrition [11], which is still highly prevalent among vulnerable groups and which affects more than one out of four in Namibia [12,13]. These fish-protected areas therefore benefit both fishers and the communities who have access to these fish as an affordable source of protein and micronutrients.

Based on the lessons learned in the pilot project phase, a systematic approach using the eight milestones of governance and management was developed to establish community-managed fishery reserves. The milestones include the development of a constitution and the election of a committee of representatives for the governance of the fishery reserve; the participatory identification of the area to be set aside as a reserve; the development of management plans; the appointment of citizen researchers to observe changes in the fish population within and around the reserve; and community police to enforce the management plan. A number of partners and stakeholders are involved in all stages of the development and approval process.

The shared nature of the transboundary rivers in the Cubango-Okavango River Basin (CORB) and the Kavango-Zambezi (KAZA) area makes regional collaboration a priority. Fishery management is only meaningful if it is implemented on both sides of the river. The successes of Namibia's approach to fishery management have had a ripple effect in the region. The approach is being replicated in the neighbouring countries of Zambia and Angola. Furthermore, a Freshwater and Fisheries Working Group was established in 2016 as a subgroup of the Kavango-Zambezi (KAZA) Conservation Working group, which is aimed at ensuring the sustainable utilization of fish resources for the benefit

of local communities, to harmonize legislation for shared fish resources, to standardize research and management protocols, and to share information and best practices between neighbouring countries.

## 2. Materials and Methods

This article is based on research that used a grounded theory approach to build knowledge on inland fish reserve management and both theoretical principles and practical management tools on the basis of the initial pilot phase of reserve development [14,15]. During this phase, sites were chosen based on meeting the dual criteria of being socially acceptable to the community managing the reserve and biologically meaningful for the fish stock concerned. The precise nature of these criteria has evolved based on collaborative learning and ongoing research. For example, understanding the key fish that are consumed by the community and the biological requirements for increasing their stock has provided all of the stakeholders with more information about the minimum size that fish reserves need to be in order to be biologically meaningful.

The data this article draws on primarily come from two sources. The first is through the application of the action research model of plan, act, observe, and reflect to the pilot phase of the fish reserves [16]. The last five years have convened various stakeholders working on inland fishery management to build pilot sites for community fishery reserves. These sites were selected through a consultative process with traditional leaders, representatives from the Ministry of Fisheries and Marine Resources, the University of Namibia, and people involved in the development sector. Over the course of developing the first fish reserves, a structured learning process took place, with each item on the timeline above representing a full cycle of planning, acting, observing, and reflecting. The first cycle resulted in a set of eight milestones that were required to establish a fish reserve. These were applied to the first 20 fish reserves, and at the end of 2021, they were reviewed through a week-long participatory workshop. In 2022, a new set of milestones and guidelines will be agreed upon, which will be based on lessons learned to date. The expectation is for these new milestones to be gazetted by the Ministry, formalizing them in the Namibian conservation policy environment.

The second source of data this article draws on are site surveys on both ecosystems and livelihoods that were conducted during the first 4 years of establishing the fish reserves. This multi-site and sometimes longitudinal data have provided a robust evidence base to understand the results of varied management practices put in place across the various reserves. At each site where a fish reserve is to be established, a Frames survey is conducted. Frames surveys are standardized internationally and include a census-based approach through which data on fishing vessels and gear operating in a certain area, and fishing trip patterns as well as the socio-economics, demography, and nutrition of fishing communities can be gathered. This provides a snapshot of the role that fishing plays in a community, which is a critical backdrop to management planning. The second survey is a biological survey that looks exclusively at the fish population in a certain area and that includes information about the species, its occurrence, and size. These surveys are both repeated on a periodic basis over the duration of the establishment of the fish reserve and have provided crucial foundational data for communities about the effectiveness of fish reserves in different areas.

These two different data sources are triangulated with an analysis of the policy environment that was prepared for the review of the milestones as well as lessons shared by the stakeholders in the fishery process to date, through the review of a combination of 16 key informant interviews, activity reports, workshop proceedings, and other relevant documents. A thematic analysis was carried out. The results of this analysis therefore structured below according to their lessons for policy, for multistakeholder participation, and for conservation outcomes. This triangulation will further inform work on the management of inland fisheries across the southern African landscape, but it also holds lessons for those

looking to develop Other Area-Based Conservation Measures (OECM) or to innovate in the field of community-based fisheries management.

### 3. Results

The section below outlines the lessons that have been learned for policy, community participation in fish reserve management, and the ecological components of fish conservation.

#### 3.1. Lessons for Policy

The initial pilot phase for fish reserves made it clear that multistakeholder engagement cannot be limited to an initial consultation process, but also must be an ongoing culture of dialogue, reflection, and learning [16]. Particularly, the convening inspectors, who are mandated to address infringements in fish management agreements and who report back to the ministry the Ministry and meet with those managing the reserves themselves, highlighted that if policy is made without the engagement from those who will implement and enforce it, then it will not be effective. One participant said, “Being an inspector is hard because there are differences. When people come with big boats, ok. Maybe you’re scared because you know they’re faster than you. But if it’s an old woman who’s coming to harvest some water plants, you know it’s not allowed but you also know that’s her dinner. And it’s not harming the ecosystem.” (I6Z4, August, 2021).

To date, significant work has been conducted to describe the current level of policy implementation, and this has made it clear that there are certain strengths and weaknesses in the policy environment to date. Capacity limitations are a constraint to policy development and implementation. A combination of both political support and implementation capacity are needed to ensure that budgets and human resourcing are in place. These capacity constraints currently limit the number of fish inspectors that can be in the field, and the resources that are available for them to patrol such extensive areas. As one participant said, “It’s a balance. You need the community to be behind the inspectors, or they won’t be empowered to enforce the rules. But also, not all communities have the resources. There needs to be more. You find there are stretches of river kilometers wide, with only one guy. And maybe he doesn’t have transport.” (IM8D, July 2021).

However, limitations are not just at the field level. There has been a provision for an inland fisheries council that has not yet been convened. With the number of fish reserves increasing, the importance of the work of this council is increasing. As one participant pointed out “the ministry doesn’t have people working in fish anymore. There was a restructuring, and everyone went to aquaculture. Inland fisheries? People weren’t talking about it. Nobody sees money in it.” (D3T, August, 2021) Another participant described the problem as “We don’t always know when to run and when to walk. There are so many communities now that see the importance of this work, and we are seeing results. But we have to be careful, because communities are different, and we want our policies to work in these different contexts.” (PR6N, August 2021) In areas where there are not enough inspectors, community fish guards have been identified as enforcing the rules, something that is supported by customary rules through the Traditional Authorities. The feasibility of this approach is based on community dynamics, which makes it difficult to scale as a model.

This raises a question about the optimal level of decentralisation for regulatory control. As one participant noted, “You need the community to own the system or it won’t work. But if everything is brought down, there is a risk. Not everyone has good will and knows about conservation. So, you also need regional and national, working together.” (XF4JT, November, 2021) An example of this debate is around the permit system, which is currently managed by the regional authorities. While the permit system generally works as needed, it does not work optimally to benefit the community, and there would be both advantages and risks to a further decentralisation of the regime. One participant said, “Lodges should be able to issue their own permits. They need conservation to survive, it would be convenient for the tourists, and then they would benefit.” (HR4NB6, November, 2021) Another

participant countered this, saying “We can’t go all the way down, or we don’t have the birds eye view. Otherwise, how do we know all the tigerfish have been taken from that part of the river, if we can only see two were taken here, three there?” (BH19NL, August 2021).

In addition to capacity constraints, there are also areas where the regulatory environment could be strengthened. A critical feature of the policy development for inland fisheries is that it has been strongly evidence driven. Namibia’s Inland Fisheries Policy (1995) was based on the best available science at the time. In the intervening 25 years, however, much has been learned about the biological characteristics of fish, about the preferences and practices of communities, and the characteristics of effective conservation.

Another example of an area in which the policy environment could be more enabling, is with regard to catch equipment. The current policy limits the size of the weave of fishing nets, with a goal of limiting catching smaller fish. While the initial results suggested that this would be an effective way of ensuring that young fish were excluded from the catch, it emerged over time that the majority of fish, particularly in flood plain environments, are small, even as adults, and excluding their catch is also excluding one of the most available and ecologically replaceable sources of protein to communities. This is an unnecessary loss for communities that has no particular conservation gain. Large fish, on the other hand, often indicate genetic success, and removing them from an ecosystem is comparatively more devastating (Hay, personal communication, 2021). This has implications for the effectiveness of limiting net mesh sizes, and the policy will evolve as additional research emerges. Another fish expert reiterated that point, saying, “This mesh size, it’s not getting the results we want. Nobody is going to fish with a large mesh because what will you catch? The policy has to also be based on reality, and on the Delta, most fish are small.” (FE8, July 2021).

Finally, there is a range of policy questions that are still contested. A significant driver of this is the diversity in both the social and ecological characteristics of Namibia’s inland fisheries [17]. A policy that regulates the fishing gear in a perennial river area may be appropriate, while applying it to a floodplain area may not make sense. However, this must be balanced against having simple and clear guidance about what is allowed and how it will be enforced. Similarly, it might be feasible to restrict the types of nets that can be used in certain waterways, but on rivers that share international boundaries, it is futile to regulate a practice in Namibia but not in the other half of the river that is managed by a neighbouring country. While there may be some social contexts in which closed seasons are respected, in communities where people depend on fish for their daily meals, it could be unethical to enforce.

The past five years of experience piloting the fish reserve model has allowed all stakeholders to better understand the advantages and disadvantages of the current inland fish policy environment. While contestations remain about many of the areas above and tradeoffs will have to be made around setting the policy agenda around ideal practices versus existing capacity, for example, there is now remarkable consensus around how stakeholders should convene towards an end goal. This means that ongoing learning will allow the policy environment to continuously improve based on the emergent data on effective implementation.

### *3.2. Lessons for Participation*

Community fisheries are an ecosystem-based adaptation approach that recognize local communities as being critical for conservation and that has the potential to generate livelihoods and ecological benefits such as healthy rivers that are sanctuaries for birds, reptiles, and mammals. Working across different ecosystems calls for flexibility, a deep understanding of community fishery behaviour, a re-thinking of the characteristics of a reserve (e.g., smaller pools, backwater channels, mainstream stretches, and floodplains with overlapping land use), and which management tools are the most feasible. Management tools include no-fishing to no-net policies or traditional-gear-only policies. The decisions that are made on each of these facets of protecting fish stocks must be tailored to local

needs. Reserves must be ecologically meaningful, socially acceptable, and within the scope of Namibian legislation.

The management plans for fish reserves are developed using all of the available information, which is validated through workshops and participatory exercises on the felt or perceived decline in fish stocks, dwindling species, and what traditional rules exist to manage the fish and other aquatic resources. Several respondents felt that it is often easier to build awareness and support for previously used rules than it is for introducing a new regulatory system due to the time involved for communication and for building buy-in. One respondent said, “So many of these approaches, we had in the 80s and 90s. They flew out the window for a while, but people who have been in the community, they know about them, and they worked.” (KD5D3, November 2021) When conducting validation workshops, it is important to include individuals from different genders, age groups, and educational backgrounds in the development process and to visualise the fishery reserve process (e.g., in poster format). As one facilitator offered, “What you never want is to go through a process and then have someone say but I wasn’t included. So, you have to invest so much time in the beginning to make sure people get the message, that everyone must come and hear. You can still have problems, but if you have been careful, you have a better chance of moving forward.” (CH5J3, November 2021).

Knowing that protection is not necessarily a blanket ban on fishing, but that there can be a spectrum of level of protection, and a menu of protective behaviours that can be agreed upon, has built increasing support for fish reserves within communities, leading to large areas being proposed for fishery reserves. It has been more important for local communities to take ownership in managing their own resources for their own benefit than to find the ideal conservation approach [18]. One participant explained that “Communities must control the principles, even if it’s difficult. Say, the river is open, but communities limit fishing from the banks. But you don’t want to make something too complicated. People will get confused if you say nets over here, not over there, but only these months. You have to decide what is absolutely most important to the community, only then you can enforce.” (SR4Z, August 2021) Given the ecological discussion below, which includes emergent research around different management strategies to better protect different species of fish, this is particularly important.

An important dynamic that emerged in the pilot phase that holds critical consideration for how community participation is conceptualized is the issue of migration and multilocal livelihoods that characterize many households in the region [19]. A critical group of people who should be involved in the process are absent community members, many of whom often live in urban areas. These community members remain connected to their households, and because they often have an interest in building additional income streams in the community or plan to move back, they often oppose new rules that would compromise future access to building small fishery businesses. These stakeholders often contribute to the local economy in important ways such as through remittances, and may have more education or access to other resources. It is for these reasons that their views are often unopposed. As one participant explained, “It’s so disheartening in a community gathering, to see the people who live by the river, who fish every day in the river, who depend on the river for their livelihoods, keeping quiet, because they also depend on that Windhoek to help their child go to university, or to do them favours. You know they want the reserve, but they won’t speak up.” (RH4J, September 2021) Another participant explained the phenomenon in a different way. “The problem is, the power in the community, isn’t always in the community. In so many places, families have people with government jobs, people who have cars. They don’t live there anymore, but no decision is made without them. And they are the ones that can come with big boats.” (HR2N36, October 2021) From a localised and practical standpoint, involving this group, understanding their interests in fish, and ensuring they receive information and are included early on in the process is the key to ensuring that decision making is not later derailed. However, more broadly, it raises questions about what the decentralisation of management looks

like in areas with polycentric governance, demonstrating that local power is not always geographically bound.

Through the legal recognition of fishery reserves, the willingness to engage in law enforcement has increased significantly. People living in riverine areas near fish reserves often struggle to understand the differences between rights, legislation, and management authorities and take a more holistic approach to the natural resources that they can access. Therefore, existing governance structures should be considered when introducing fishery reserves. In the Namibian case, conservancies, which are designed for the management of wildlife and tourism have long-standing community engagement structures, and lend themselves well as a vehicle of engagement with the natural resource management rights that communities already have. An additional benefit of “nesting” a fish reserve within a conservancy is that it can create a landscape approach to make management more viable by integrating the management of a more diverse range of resources, securing channels, which are often wildlife corridors over waterways and that contribute to combatting wildlife crime. A limiting factor, however, is a situation where community dynamics limit cooperation around natural resource management. A fishery reserve then forms part of the same dynamics rather than being able to develop an additional node of authority. One participant noted, “You can say that having the conservancy there is perfect because there is already an engaged community there to communicate with the people about conservation. They know the concerns, they know how to get people on board, and it’s great. But you also find in some communities, it’s already not working. Maybe someone is trying to use his position in the conservancy for his own benefit, or there is some argument that is dividing the conservancy. Then if you work with them, you are also inheriting their problems.” (CL1B6, July 2021).

### 3.3. Lessons for Conservation

The fish from the Okavango River have received comparatively little attention in the past, with the Delta being the main source of interest [20–23], and some studies focusing on the potential impact that the proposed Eastern National Water Carrier at Rundu could have on the fish population [23–26]. One of the first detailed ecological studies on the fish in the Namibian section of the river was conducted by Van Zyl [27], which also focused on the subsistence fisheries. Hocutt et al. [28] and Hay [17] developed an index of biotic integrity based on fish, providing an overview of the health of the system. The index showed a decline in the catch rates between the mid-1980s and mid-1990s due to intense fishing by the communities and a slight decline in the state of the aquatic vegetation. Similar trends were observed with higher catch rates and bigger fish in the Mahangu Game Park, where no fishing is allowed, compared to the rest of the river, where fishing is carried out by communities using a variety of fishing gear [29,30]. Fishing during the 1980s was almost exclusively for the catcher’s own consumption [31], with few gillnets being found by Hay [32] in the early 1990s. This situation changed around 2010, when large numbers of gillnets and dragnets began to be used by fishers (R. Burger, personal communication, 2020). Recent monitoring surveys conducted by the Ministry of Fisheries and Marine Resources show low catches in their experimental gillnets (F. Jacobs, personal communication, 2021). Unfortunately, the Mahangu Game Park, which is considered a fishery reserve by default, is under fishing pressure from fishers from outside of the area, with declining catches being reported by the Ministry of Fisheries and Marine Resources during their annual monitoring (F. Jacobs, personal communication, 2021).

The biggest threats to the fish population along the Namibian section of the river are the use of large dragnets, especially during low-water periods (September to December); when large tilapia species congregate in the shallower sections of the river to breed, the use of drift nets targeting tigerfish and the use of very effective, but illegal, monofilament gillnets are problems. The increase in the human population along the river and the influx of outsiders coming to fish increased fishing efforts. Other potential threats are the introduction of alien fish species and the predicted impact due to climate change. Nile

tilapia (alien fish species) were introduced in dams in the Okavango River upstream in Angola for aquaculture purposes [33] and are likely to move down into the Namibian section of the river and the Delta in Botswana. The Nile tilapia is an aggressive species and will compete with the native Threespot tilapia and Greenhead tilapia. They are also likely to hybridise with the Threespot tilapia, diluting the genetic fitness of these native species.

Fishery reserves are recommended as a potential measure to protect fish stocks [34–36]. Questions have been asked regarding whether these protected areas will also benefit migratory species such as tigerfish and catfish. Work by Jacobs et al., (2019) showed that a 10 km river stretch is likely to protect 50% of the tigerfish population 75% of the time. Large tilapia species such as Threespot Tilapia, Greenhead Tilapia, and Nembwe show relatively small movement behaviour, making protected areas an excellent management tool to protect these highly valued fish species. These protected areas can be quite small if they are strategically located [27,35].

A study conducted on the first proclaimed fishery reserves in the Zambezi River in Namibia showed higher catches in the reserve compared to those outside of the reserve, a higher species diversity (those species targeted by the fishers, and bigger fish for some of the tilapia species [10]. Furthermore, this study resulted in the emergence of several initial benefits related to fish reserves despite the relatively short period of protection:

- Catch rates and fish species diversity were higher and fish were growing bigger.
- Fishers indicated higher catch rates when fishing closer to fisheries reserves.
- Fishers stick to the rules according to the Inland Fisheries Resources Act when fishing in the vicinity of fishery reserves compared to in fishing grounds further away.
- Less damage to aquatic habitats due to fishing activities.
- Income generated from tourism at fisheries reserves that are near lodges.
- Hotspots for recreational fishing.
- Voluntary support from the private sector and tourism industry.

With the increase in the riverine population and the subsequent increase in the demand for protein, protecting fish stocks is becoming increasingly difficult, and the government has inadequate resources to manage these concerns. The nature of the shared fish stocks with Angola, which has a different regulatory environment around fishing as well as varied capacity for enforcement, further hinders effective protection. The most effective approach is to empower communities through the establishment of fishery reserves that they manage with support from the government and private sector. However, this must be coupled by ongoing evolution in the policy environment to ensure coherence in the regulatory environment as well as ongoing research, which will help communities identify which management practices are the most effective in the context of their localised inland fishery environment.

Table 1 provides an overview of some of the socio-economic data recorded along the Kavango and Zambezi Rivers in different communities. Fish consumption and food security levels vary between the different communities. Low levels of fish consumption are most likely due to the unavailability of fish rather than a distaste of fish as a protein source.

Table 1 below illustrates the diversity of roles fishing plays in riverine communities across the Kavango and Zambezi rivers. In some communities, fish is the main source of income of nearly half of the respondents, while in others, it only supplements the diet of households. This also correlates strongly to the gender breakdown of people participating in fishing, with men engaged in fishing in those communities where fishing generates income, and women equally engaged in fishing where it is primarily for subsistence consumption. Clearly, the way that households engage in fishing activities and fish consumption, and the way that they benefit from fish resources has implications for the kinds of protection activities that will get support from communities.



**Table 1.** Summary results of socio-economic surveys at different sites along the Zambezi and Kavango Rivers. (Z = Zambezi River; K = Kavango River).

Area	No Balanced Diet	Some Times No Food for 24 h	Fish Consumption (atLeast Twice) Per Week	Fish Consumption Per Week	Meat Consumption Per Week	Pulses Consumption Per Week	Protein Consumption Per Week	Grain Consumption Per Week	Vegetable Consumption Per Week
Nsundwa (Z)	15%	40%	84%	5	0.3	0.8	6.1	1.6	2.4
Ikaba (Z)	17%	53%	76%	5	0.8	1.1	6.9	1.7	3.8
Maurus Nekaro (K)	3.6%	75%	89%	4	1.5	1.9	7.4	6.32	5
Joseph Mbambangandu (K)	1%	66%	28%	1.4	1.1	0.6	3.1	3	4.5
Kapinga Kamwalye (K)	100%	97%	80%	3.1	2	2.1	7.3	5.9	5.1

Fish are seen as a major source of income in the communities of Nsundwa, Ikaba, and Maurus Nekaro, with the average monthly income being as high as NAD 3000. Fish are also often consumed in these three communities (Table 1). Employment rates are very low, with 2 to 12% of these communities being officially employed. As Table 2 illustrates, fishing activities are gender segregated in some areas, where men carrying out most of the actual fishing, and women being involved in the processing and vending of the fish. The fishing that is carried out by women is often with traditional fishing gear or with mosquito nets targeting the small-sized fish species for their own consumption. Large tilapia, tigerfish, and catfish are caught by men using gillnets and are either sold locally or, in the Zambezi Region, at the Katima Mulilo fish market.

**Table 2.** Selected results from Frame surveys in five communities, focusing on fish as a source of livelihood. (Z = Zambezi River; K = Kavango River).

Area	Number of Respondents	Fish as Main Source of Income	Engaged in Fishing	Men Engaged in Fishing	Women Engaged in Fishing	Income Generated from Fish	Employed
Nsundwa (Z)	57	47%	50%	100%	0%	Av. NAD 2376.00	7%
Ikaba (Z)	86	61%	55%	70%	29%	Av. NAD 3050.00	12%
Maurus Nekaro (K)	55	48%	87%	46%	37%	NAD 100–NAD 3000	2%
Joseph Mbambangandu (K)	96	7%	64%	56%	42%	NAD 210–NAD 760	11%
Kapinga Kamwalye (K)	35	3%	74%	50%	50%	NAD 100–NAD 500	3%

What the results of the Frames surveys illustrate in Tables 1 and 2 above is that fish play different roles in each community based on the local economy, geography, and ecology. In some communities, fish are a primary source of income for more than half of all of the respondents, while in other communities, virtually nobody within the community relies on fish for income. Similarly, in some communities, fishing is exclusively carried out by men, while in others, there is an equal gender balance in terms of fishing activities. This information is critical in shaping how a fish protection area could be both socially acceptable and ecologically meaningful.

#### 4. Discussion and Conclusions

Establishing fish reserves for Namibia's inland fisheries has required complex institutional arrangements and buy in from a variety of stakeholders with divergent capacities and interests. These experiences hold important lessons for other complex, collaborative, and landscape-level management arrangements. Given the deterioration in fish stocks over the last two decades, there was widespread agreement among stakeholders that the need to establish a sustainable use system was urgent. A collaborative learning was a process identified to allow to communities to identify protected areas that are both socially acceptable and ecologically significant was developed after only a decade. Having further tested this process in 20 locations over the past 5 years, there is now a refined understanding of the roles and responsibilities of different stakeholders, of the preconditions for the success of the reserve, and perhaps most critically, of the promise that fish reserves hold for rehabilitating inland water ecologies.

Biological research from the fish reserves that have been piloted has demonstrated that protected areas have both higher catch rates of bigger fish, discussed above. Reports from fish inspectors show that where communities have driven the implementation of the reserve model, compliance with the agreed upon restrictions is high and that mobilization to limit rule breaking by outsiders is more feasible. However, this requires an ongoing process of continuous education and the demonstration of the value of the reserves. There are multiple opportunities to raise awareness around these reserves, including data collection from Frame surveys, engagement with traditional leadership, and communication channels such as community radio. While no single intervention area will ensure the success of a fish reserve, through a better understanding of each stakeholders' role and how agreement

on collective interests all have an impact on increasing inland fish stocks, momentum for fish reserves can be built.

Namibia's inland fisheries are a particularly complex conservation dilemma, which makes them a particularly good case for innovation in protected area regimes. An adaptive, process-based approach that allows for local variation in management practices is critical given the geographic, social, and ecological differences and the different management practices that they demand. However, this also requires tradeoffs with guidelines that are sufficiently simple and generalisable in order for them to be understood and applied across these various contexts nationally. The experience of establishing fish reserves has demonstrated that the community ownership of resources is essential for solving many conservation problems but that certain social and ecological preconditions are required for success. Ongoing learning and adaptation across national and ecological contexts will allow for stronger synergies in collaborative landscape planning.

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