Holes in the Policy Net: An Analysis of Sustainable Food Production in Artisanal Fishing Communities and Policy Challenges to Ensure Long-Term Food Security in Sofala Bank, Mozambique

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1 Introduction: Setting the Scene

Mozambique is projected to become the World's second most vulnerable country to resource scarcity and climate-related disasters by 2050. It is the Sub-Saharan country facing the highest risk of ecological threats (IEP 2020). Also, it ranks 103rd of 107 countries in the Global Hunger Index (GHI 2020), making food security an essential future risk and policy focus (WFP 2020). Globally, the frequency and magnitude of climate-related impacts are expected to increase with climate change. Here, low-income countries are projected to becoming the most vulnerable (IPCC 2014). The design and implementation of climate adaptation policies to build-in resilience and disaster risk reduction are complex processes in low-income countries (IEP 2020; Mucavele 2014).

Despite political, economic, and knowledge-based challenges, Mozambique has made progress in developing its disaster risk reduction policies (Koivisto 2014) to meet climate change threats (Ferrão et al. 2018; IEP 2020; USAID 2018; WFP

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2020). Furthermore, progress has been made to achieve sustainable fishing policies, protecting fish resources and ecosystems (Ministério das Pescas 2010; REPMAR 2020). This makes Mozambique an interesting case to study such management policies' effectiveness by assessing their effects upon the actors and their reactions. The paper focuses on analyzing an essential aspect of Mozambique's future food security by addressing rural coastal communities where the primary sources of food are fishing and agriculture. We evaluate the effectiveness of existing fishing management policies and their interaction with rural fishing communities' life practices and their daily income and subsistence possibilities. This involves analyzing the interconnectedness between and obstacles faced by policy objectives and the specific characteristics of and challenges to rural coastal fishing communities' livelihoods.

We examine the following hypothesis: There are ways in which future fishing policies can ensure food security for local coastal communities and effectively regeneration and conservation of shrimp resources.

This paper defends the idea that there are untapped alternative solutions to implement sustainable and effective policies that will benefit ecosystems and human settlements. The need for climate-proof solutions is emphasized, given the strong connection between food security and climate change.

The chosen case study is a Sofala Bank Coastal community representing other fishing communities along the Mozambican coast. This anthropological study focuses on the daily practice of artisanal fishers. Coastal regions are essential when addressing food insecurity and climate change challenges in Mozambique. In recent years, they face increasing population pressure due to food-scarcity-related migration from inland areas. Here droughts have caused failed harvests and food scarcity (Mucavele 2014). Sixty percent of Mozambique's population already lives in coastal regions (Hoguane 2007; UNCTAD 2017). Of these, twenty percent depend on artisanal multispecific fishing, with shrimps being the most valuable resource. Coastal communities rely on fisheries as the primary protein source in their food diet, while small-scale agriculture is a complementary subsistence activity (Hoguane 2007; MIMAIP 2018; Palha de Sousa et al. 1995; Sousa et al. 2011).

Presently, the coastal communities are in a situation of persistent food insecurity, while at the same time, they exert constant pressure on fish resources (UNCTAD 2017). They constitute a threat to the good health and sustainability of the marine and estuarine ecosystem. Ecological vulnerability, unsustainable fishing practices, and management failures create a risk of ecosystem breakdown. An enclosure period policy has been implemented, where fishing in coastal ecosystems is prohibited for all fishing sectors (industrial, semi-industrial, and artisanal). The objective is to reduce the pressure on fish resources (REPMAR 2020).

In Mozambique, artisanal fishing is a highly ranked activity for the local labor force since it generates income and is a source of food security. Simultaneously, it has been found necessary to target artisanal fishing methods (Sousa et al. 2011), in the most recent fishing regulations (MIMAIP 2020; REPMAR 2020; Sousa et al. 2011). However, little social fishery research has been conducted to guide fishery management (Afonso 2010), such as conservation of coastal resources and artisanal sub-sector catches (Pereira et al. 2014), or fisher practices and lifestyle.

The sociology underlying the perceptions, behavior, practices, and motivational drivers of Mozambican coastal fishers is unknown. The existing data is limited. The few research analyses are based on quantitative statistical data and analyze the fishermen's responses to specific management policies (IDPPE 2013a; MIMAIP 2018; Santos 2008).

It is necessary to understand further the broader interconnections between the fishermen's behavior, policy measures, and ecosystem conservation, and the need to protect the marine ecosystem and ensure the coastal population's livelihood and sustainability. This process requires evaluating policy effectiveness by examining the everyday activities of artisanal fishers and possible obstacles on the ground. To test our hypothesis, we first address three key food security challenges in coastal Mozambique and then consider a fishing community's daily lives and practices via a case study in one of the 200 fishing centers in the Sofala Bank Delta (Fig. 1a).

2 Case Study Background and Methodology

The case study background and the physical field.

The Zambezi River is one of Africa's longest rivers and is located in southern Africa. Its sources are located on the Lunda threshold in Zambia on the border of the Democratic Republic of Congo and Angola. The river stretches for a total of 2736 km. Its catchment area is 1.33 million km^2. The river flows through Zambia, Angola, and Mozambique, before emptying into an 880 km^2 delta in the Indian Ocean (Gammelsrød 1992).

The Zambezi River is the largest of about forty rivers that discharge onto the Sofala Bank (Pereira et al. 2014). The river estuary systems of this low-lying coastal zone comprise around 200 fishing communities (IDPPE 2013b) along its 700 km coastline (Google 2021) (Google maps). It is a region with 801,590 km^2, dominated by mangrove forests as the primary vegetation.

Several rivers discharge onto the bank, with the Zambezi River being the main source of freshwater. As a consequence, the bottom topography on the bank consists predominantly of fine gravel and sand sediments from Zambezi runoff.

The Zambezi river delta is the most crucial ecological habitat on Mozambique's coast and is one of the most productive penaeid shrimp ecosystems in the western Indian Ocean (Hoguane 2007; Malauene et al. 2021). The case study area (Fig. 1b) comprises the fishing communities of Chuabo Dembe and other fishing centers and markets located near the Bons Sinais estuary. Most of the region covered is in rapid urban expansion but still retains rural characteristics. The Bons Sinais estuary crosses Quelimane, the principal city of the Zambézia province, and some fishing villages, such as Chuabo Dembe village, where the local population lives just next to the river.

According to reports from the local population, the first settlements at the Chuabo Dembe fishing village date back to the 1980s, when the civil war broke out in Mozambique. The war resulted in a massive exodus of people from the rural areas to seek protection close to cities. Because of its strategic location up-river, protected by the

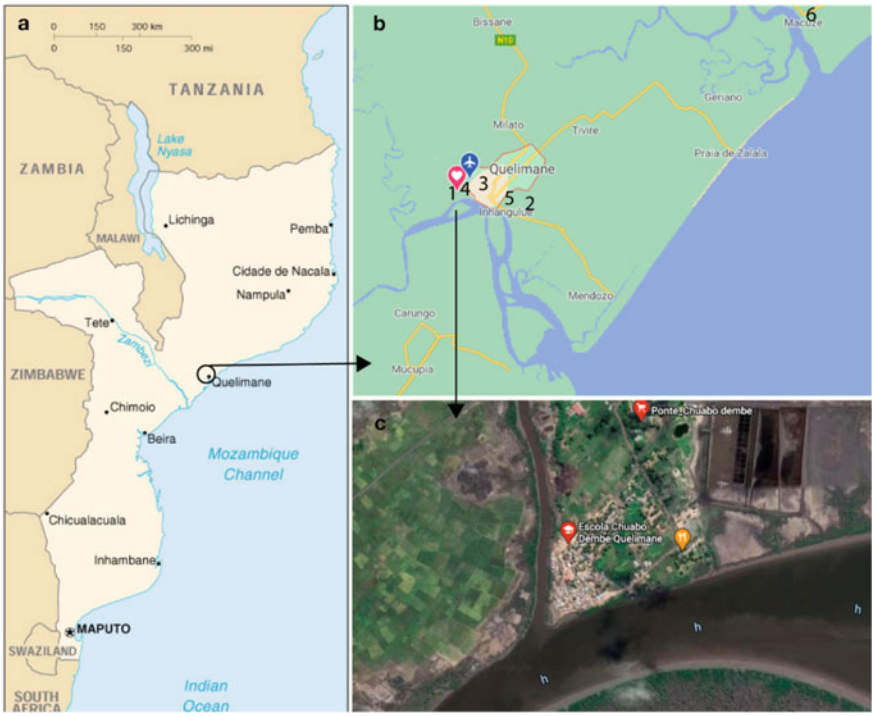

Fig. 1 **a** Map of Mozambique showing the main Zambezi River and Sofala Bank. **b** Map of the relevant communities in the Zambezi River Delta—field study locations "Chuabo Dembe village", Sofala District (1) and the five secondary fields of data collection "Icidua Fish Trading Center" (2), "Quelimane Central Market" [Mercado Central] (3), "Fai Market" [Mercado de Fai] (4), "Icidua Market" [Mercado de Icidua] (5), Sofala District, and the "Marcuse estuary", Namacura District (6). (c) "Cabo Dembe village". Data sources: FAO (2004) **a**, Google maps **b** and **c**

city of Quelimane, and its proximity to the estuary, fishers from other coastal areas started settling in the area, establishing a fishing village. The village houses are built with local material, wood extracted from mangrove trees and clay, and zinc sheet roofs (Fig. 1c). About 2 km from Chuabo Dembe is the tiny Fai Market (Fig. 1b). Here, fresh and dried shrimps and fish are sold, providing protein, mainly to the surrounding neighborhoods. The majority of the fieldwork was carried out in these two locations.

3 Methodology

The research design drew upon qualitative and quantitative methods involving literature review, anthropological participation, semi-structured interviews, and user surveys.

To test our hypothesis, we did a literature review of Mozambican fish policies 1980–2021, the penaeid shrimp life cycle, and developments in Sofala Bank coastal fishing focusing on artisanal fishing practices. The field study focused on two fishing communities and four related fish markets (Fig. 1).

The case study concentrated on Chuabo Dembe village, aiming to understand the life practices of artisanal fishers and analyze the effectiveness of fish policies on the ground. We tested our hypothesis by exploring the untapped potential of sustainable solutions for fish resource conservation and food security in coastal Mozambique.

The case study was conducted from December 2017 to August 2018 at Cabo Dembe fishing center. We followed the fishers' activity on land and on the river between January 2018 and August 2018 (36 visits), participating in fishing activities at Bons Sinais estuary from the Chuabo Dembe fishing center to the farthest point in the direction of the river mouth, covering a distance of about 10 km of the river length. The Bons Sinais estuary is about 30 km across.

Our sample included 37 fishers, which is about 40–50% of the entire fisher population. According to local fishers, there are between 70 and 96 artisanal fishers in Chuabo Dembe. According to national statistics, there are 69 nets and 60 boats in Chuabo Dembe (IDPPE, 2013a). Since official statistics do not include social variables such as age, it was less possible to analyze whether our sample was representative compared to the population (e.g., a one-sample t-test).

Both qualitative and quantitative methods were used in the present research. The main data collection source was participant observation and interviews, while catch composition samples were carried out and collected among fishers in the Chuabo Dembe fishing village (with around 250 households).

For this study, the analysis was divided between two fishing periods: (1) The normal fishing period and (2) the enclosure period for shrimp fishing. During the field study period, the enclosure period was announced on 12th November by the national fishing authorities (ADNAP). For artisanal shrimp fisheries, shrimp's enclosure period covers the period from 1st January to 28th February. During this period, it is not allowed to catch, sell, and transport shrimps caught in the Sofala bank. Furthermore, the use of nets with small mesh sizes is prohibited in estuaries and coastal areas.

Supplementary data were obtained from secondary sources, including analysis of artisanal fishing census information (IDPPE, 2013c), national fishing regulations (REPMAR 2003), decrees, and policy statements from national profile sources such as the Small-Scale Fisheries Development Institute (IDPPE), the Ministry of Fisheries (MIMAIP), the Council of Ministers, and reports from the National Institute of Fisheries Research (IIP).

4 Results

Three key challenges

Overfishing is a threat to ecosystem conservation

In Mozambique, three types of fishing contribute to 3% of BNP and 4% of exports. Commercial sectors (industrial and semi-industrial) exploit the most valuable Sofala Bank fish resources, e.g., shallow and deep-water shrimps and fish species, such as tuna, billfish, and sharks (Pereira et al. 2014). Artisanal fishing operates mainly in the shallow waters of estuaries. It is practiced for subsistence and commercial purposes, involving fishing communities and actors in the value chain, e.g., fishermen, processors, fish transport, traders, input suppliers, boat carpenters and technicians, and net maintenance (Afonso 2010). It is the most productive activity, accounting for about 90% of annual catches (MIMAIP 2019; Pereira et al. 2014). This sub-sector is of great social importance. Coastal communities, representing 2/3 of Mozambique's population. For them this sub-section is the most critical food source and also for employment (Afonso 2010; Pereira et al. 2014). In addition to fishing, the households are involved in agriculture as the second subsistence activity and exploitation of forest resources (e.g., selling firewood and coal, mainly in coastal areas close to urban centers).

Artisanal fishers operate in nursery grounds in shallow coastal waters, covering coastal environments in rivers, bays, estuaries, and shallow beaches. The fishing activity is carried out using "dugout canoes" and other non-motorized vessels. Less than 3% of artisanal fishermen's boats are motorized (IDPPE 2013b). Approximately 50% of artisanal fishers operate without the use of boats.

The fishers use different types of fishing gear, "conventional beach seine" (trawling net), and non-conventional fishing gear such as "Chicocota" and "mosquito nets" (Pereira and Brito 2008). These are all considered inappropriate fishing methods, harmful to the ecosystem and the shrimp stock (ASCLME 2012; Chaúca and Álvaro 2010; Hoguane 2007; Pereira and Brito 2008; REPMAR 2020).

Since 2000, an increasing number of non-selective fishing gear has aggravated shrimp stock decline (Chaúca and Álvaro, 2010; IDPPE 2013a, 2004; INIP 2015). Non-selective fishing gear has a small mesh size, leading to the catch of a large number of larvae and juveniles (Chaúca and Álvaro 2010), and reducing the rate of recruitment to the open sea, especially in the rainy season (Brito and Pena 2007; Palha de Sousa et al. 1995).

Penaeid shrimp live in tropical and subtropical waters. The lifecycle of the shrimp larvae starts in the ocean with adult shrimps. The post-larvae migrate to the river estuary. The estuarine environment is used to grow from larvae to juvenile (Garcia 1981), making the estuary a critical nursery ground and ecosystem for the penaeid larvae and juvenile's survival and growth. The estuary is rich in nutrition carried by the river (ASCLME 2012; Gammelsrød 1992; Hoguane 2007) and the mangrove

roots retain the nutrients, protect from predators, and ensure a food-rich environment (Nagelkerken et al. 2008). The juveniles return to the sea to complete their development as adults (Dall et al. 1990; Garcia 1988, 1981).

The industrial, semi-industrial, and artisanal fishing sectors compete over the same resources. Thus, it is essential to consider all three sectors when designing fishing management solutions. Historically, the two industrial sectors have been responsible for the largest production of shrimp catches. However, from 2000 to 2019, their catches declined more than 60%, from 8755 to 3279 tons. During 2012–2013, the catches reached a low of 2000 tons annually, leading to concerns about the possibility of a fish stock collapse. On the contrary, artisanal fish catches increased almost 280%, from 1367 tons in 2006 to 6295 tons in 2018 (MIMAIP 2019, 2018).

In conclusion, the shrimp stock's sustainability is in danger if adequate policy measures are not implemented.

Current Fishing Management Policies Provide a Threat to Fishing Communities' Daily Food Supply

Due to the penaeid shrimp's economic importance, management policies were initiated during the 1960s to avoid overexploitation. Until the 1990s, regulations focused exclusively on the industrial and semi-industrial sectors operating on the open sea (Pacule and Baltazar 1992; Palha de Sousa et al. 1995; Santos 2008). For these sectors, an enclosure period has been established since 1989. It increased from 15 days to 5 months in 2020 (MIMAIP 2020; Sousa et al. 2011).

The artisanal sector, operating in the estuaries and shallow coastal waters, remained under-researched and poorly managed until about 2000 (Pereira et al. 2014). Researchers argued that the estuary is critical for the penaeid's recruitment (Chaúca and Álvaro 2010; Garcia 1988; INIP 2015; Palha de Sousa et al. 2015; Pereira and Brito 2008; Silva et al. 1995). Continuous drastic declines in the industrial shrimp catch since 2000 have led to stricter fishing regulations, also targeting the artisanal sector (Sousa et al. 2011). A three-month enclosure period for artisanal fishing has been recommended since 2010 (Chaúca and Álvaro 2010; Palha de Sousa et al. 2015). In 2014, the government implemented a one-month enclosure period (January) (IIP 2017), expanded to two months in 2018 (January and February) and five months in 2020 (MIMAIP 2020; REPMAR 2020; Sousa et al. 2011), the latter having the same number of prohibition days as the industrial sectors.

Establishing the enclosure period ensures the protection of nursery grounds for the penaeid larvae and juveniles within the estuarine habitat where artisanal fishery usually targets them. It promotes a higher rate of migration of juveniles to open sea fishing grounds. Because of this the industrial and semi-industrial sectors are ensured higher catches (Palha de Sousa et al. 2015, 1995; Silva et al. 1995), but no changes in the fish catch of the artisanal fishers. Since most of them do not have motorized boats, they don't have access to open sea fish resources (Ministério das Pescas 2010; UNCTAD 2017).

In conclusion, the efficient implementation of current management policy aims to benefit ecosystem resilience and shrimp reproduction. However, while the industrial fishing sector is expected to obtain increasing catches due to the enclosure period for

artisanal fishers, these regulations do not contemplate economic support for artisanal fishers during the five months of prohibition. There are no direct incentives for the artisanal fisher to stop fishing during the enclosure period and comply with the regulatory policy. Moreover, the ongoing policy does not have a legal framework for artisanal fishers to address their immediate subsistence needs, especially their daily food needs, during the 5-month enclosure period.

Climate change is a threat to present and future food production (fisheries and agriculture)

Future food security is connected to climate change-related impacts. In Mozambican 2/3 of the coastal areas population are projected to be affected and thus highly vulnerable to rapid-onset disasters (e.g., cyclones, storms, salt intrusion, and flash floods) (WFP 2021). The latter reduces soil quality, with the associated risk for crops (via irrigation with salty river water). Thus, future food production is endangered. Additionally, this threatens the availability of drinkable water near the villages. In essence, a greater prevalence of storms in the Mozambique Channel and increasing sea surface temperature and ocean acidification will negatively affect coastal ecosystems and fisheries.

In recent years, the human pressure on coastal areas and river ecosystems, i.e., overfishing, has increased due to migration from in-land Mozambique, caused by droughts and failed agricultural harvests (UN; 2017). On the other hand, more frequent tropical cyclones and sea-level rise will amplify coastal erosion in the near-term future, threaten habitats, houses, and infrastructure, causing forced migration away from coastal areas (WFP 2020).

The coast's geomorphology is described as low areas, with a maximum altitude of about 200 m above average sea-level. In the South, the coastline is portrayed as intermittent stretches of sandy dunes, beaches, and coastal bays and lagoons; in the Center as mangrove swamps; and in the North by dense and extensive vegetation. In the North, you also find islands, rocky beaches, and coral reefs (Hoguane 2007). Thus, the area is vulnerable to sea-level rise and tropical cyclones that produce floods and destruction (IPCC 2014).

It is likely that the frequency and magnitude of climate-related threats will increase in the near and long-term future. This may cause additional pressure in Mozambique and shaping new challenges (Koivisto 2014; USAID 2018; WFP 2020). A combination of three main stressors, rising sea-levels, warming and acidification of the ocean, and increased risk of tropical cyclones, are a threat to rich marine ecosystems, human habitats, and fishing. It is causing damage to ecosystems such as coral reefs, mangroves, and seagrass, leading to biodiversity losses (IPCC 2014).

To address their food needs and livelihood income, Mozambique's rural communities are highly dependent on natural ecosystems for fishing, agriculture, and forest products. These natural resources are projected to be highly impacted in the future climate (IPCC 2014; USAID 2018; WFP 2020).

In conclusion, fishing management has to find resilient solutions to adapt to present and future climate impacts. It is crucial to improve middle and long-term adaptation

to climate change to meet future food security risks, including the protection of water resources, agriculture, and coastal zones.

Case study: Artisanal Fishing Activities in the Bons Sinais and Marcuse estuaries in the Sofala Bank

I'm sitting on the canoe. Antonio has paddled six hours—three hours going out and three hours going back from the estuary's coastal fishing area. Today the water is 'agua turva' [turbid water]—visibility is less than 30 cm. The fishers would say that this is a perfect day for shrimp fishing (Fieldnotes (Halaze Manhice), September 2017).

The fishers' monthly work periods are centered around the spring tides, amounting to around 15 working days a month, depending on the tide and lunar cycles. However, the work is intense and demanding, with about 3–4 h of rest between the two daily trips to the river to set and empty the nets. In general, the men fish, while the women process (e.g., dry the fish) and sell the catches. Often women sellers buy the catch directly after the fishers arrive in the village and take it to the local market (Fig. 2).

Daily life is a struggle for food. The fishermen and their families live by the river, and their daily existence depends on what resources they get from it.

We are just arriving at the village after seven hours on the river. We see the industrial fishing boat parked by the edge of the riverbank. I know these ships go up-river to hide from storms in the open sea. We see village women, including the fishermen's wives, leaving the ship with plastic bags full of frozen fish on their heads. For industrial ships, shrimps are the primary target and fish a bycatch that is often discarded in the sea. Antonio explains that it's a recurring practice that women are invited to the industrial fishing boats. Married or not married, they get frozen fish in exchange for their sexual services. (Fieldnotes (Halaze Manhice), September 2017).

Sometimes the women sell their bodies to industrial fishers for frozen fish. This indicates the importance of fish for locals and shows how the village practices are centered on the river. In the last few years, due to reduced catches, the industrial boats have started selling the bycatch to artisanal fishers who approach the boats, and for about 400–600 meticals (€4.5–7) get 10 kilos of frozen fish to resell, especially for urban residents who can afford to pay for it.

None of the fishers are engaged in an alternative income-generating occupation, e.g., to provide income or food for their families during the enclosure period. 88% of those interviewed had no savings or any financial support. 12% of those interviewed were involved in community-saving schemes (Fig. 3).

Multispecific fishery

The shrimp is captured in a multispecific fishery where fish is the most abundant resource.

The artisanal fishery comprises multispecific catches where juveniles of penaeid shrimps are the main target because of their economic value. During the period under analysis, fifteen fish families were identified. In the catches, shrimps constituted 94% of the total number of individuals (6700 fish, shrimps, mollusks, etc.) and 64% of the sample's total weight (approximately 12 kg). This characteristic of the

Fig. 2 Artisanal fishers in dugout canoes setting nets. March 2021. *Photo* Halaze Manhice

Fig. 3 Photograph taken at Cabo Dembe village, showing how the local community dries the small shrimps (left) and mixed species of small fish on a mosquito net. *Photo* Halaze Manhice

fish catches shows the ecosystem's role as a nursery ground for those highly commercially valuable fish species and many crucial demersal fish species. A general catch composition comprises a mix of "buero buero" [a small shrimp with the same size as penaeid juveniles], small fish, mollusks, mudskippers, crabs, and juvenile penaeid shrimps (between 4 and 5 cm on average).

In Bons Sinais, artisanal fishing bycatches (e.g., buero buero, sardinella, and all kinds of small-sized catches) are used by local communities as a protein source in their food diet and to supply nearby markets. At the same time, penaeid shrimp is the main income source. In contrast, the bycatches of the industrial and semi-industrial fisheries constitute about 90% of the total catch, and most are discarded in the sea due to their reduced commercial value (IIP 2018; Sousa et al. 2011).

The fishers, boats, and gear

Two types of artisanal fishers can be identified: commercial and family. However, the fishing activity in Chuabo Dembe has a primarily commercial focus, with most of the catch being sold for resale. Additionally, the relationships between the fishers and the village consumers (sellers, traders, fishers, community members) are mainly kin relationships. All refer to each other as auntie, uncle, brother, cousin, etc., indicating close family relationships. Fishing is demanding and exhausting, and fishers are, in general, proud of their occupation.

Fishing was a family tradition for 63% of the fishers interviewed (either their father (63%) and/or grandfather (54%) was/is a fisher). 90% perceive there is an increase in the number of fishers in the area. Additionally, several more experienced fishers have noticed a decrease in precipitation during the rainy season and increased storms and floods. Some were aware of the impacts of climate change on the environment.

Besides decreasing wood availability, mangrove deforestation also harms fish and prawn populations and increases coastal erosion.

100% of the interviewed fishers were men. They had between 1 and 32 years of experience. Their average age was 32 years (between 16 and 53 years). The majority (67%) were between 16 and 35 years.

The two types of non-motorized fishing boats in use are dugout canoes and rowing boats. However, part of the fishing activity is conducted without using a boat, shallow water sites, or low tide. The most widely used 'boats' to carry out fishing activities are canoes (67%), "lanchas"/rowing boats (25%), and others (12.5%).

On average (during the fieldwork period), each net could make around 1200 meticals (€14) per day and 6000 meticals (€70) per working week (about two weeks per month). The sales and catches are divided between the owner (50%) and two fishers.

Three types of fishing gear were observed to catch shrimps in the estuaries covered by the study: (1) beach trawling, (2) the chicocota, and (3) mosquito nets.

5 Types of Fishing Net in Use

Chicocota and mosquito nets. Although prohibited, these nets are used by local fishers all year round. They are considered destructive for the ecosystem with high impacts for marine species in their early life stages, impacting stock regeneration (Chaúca and Álvaro 2010; Pereira and Brito 2008).

Chicocota is a trap-type fishing gear built and based on old netting, and takes the form of a funnel, with the bag usually made of mosquito nets, therefore of tiny mesh. This trap is placed in places with water currents at low depths, such as the mouth of rivers and other coastal areas (Pereira and Brito 2008). The Chicocota fishing gear is usually anchored in the estuary's narrow arms, secured by cables attached to both sides of the river, in mangrove trees, buried or attached to rocks.

Beach trawling is used in shallow waters, mostly with a sandy bed, involving about 5–12 fishers, several canoes, and a boat. The activity is carried out at low tide, allowing fishers to walk along the banks to perform the drag.

In general, the shrimp moving with the tide are swept with other organisms into the capture bag formed by a thin cloth.

Gillnets are allowed during the normal (legal) fishing period (April–October). Chicocota and mosquito nets are considered illegal (Ministério das Pescas 2010) and, since 2020, beach trawling is also prohibited (REPMAR 2020). As illustrated in Table 1, only three out of the 37 fishers interviewed said they use gillnets. However, we didn't observe any gillnets in use during the fieldwork period (December 2017–August 2018). We observed 40 nets in use during an average day over the two-month artisanal enclosure period (January–February). During the normal fishing period, the two illegal nets—Chicocota and Mosquito nets—were used.

Authorities do not officially recognize Chicocota and mosquito nets. Although prohibited, these nets are used by local fishers all year round. They are considered

Table 1 The use of fishing nets observed in the survey, outside, and during the enclosure period. Observation period from August 2017 to August 2018

Fishing gear		Enclosure period		Normal fishing period	
		Survey (number of respondents using the nets)	1-day observation	Survey (number of respondents using the nets)	1-day observation
Chicocota[a]	Illegal	8	15	12	22
Mosquito net[a]	Illegal	8	4	3	4
Beach seine (trawling) [b]	Allowed until 2020	8	21	22	42
Gillnet	Allowed	3	0	0	0

[a] Fishing nets that are considered illegal since the first fishing regulations
[b] According to the most recent fishing regulation (REPMAR, 2020), "beach seine (trawling)" is not allowed. However, during the field study in 2018, the nets were allowed during the normal fishing period.

destructive for the ecosystem and harmful for the fish stocks (Chaúca and Álvaro 2010; Pereira and Brito 2008).

6 Knowledge of the Law

About two-thirds of the fishers (65%) stated that they needed to have a fishing license to carry out their fishing activities, while 85% knew about the enclosure period. Furthermore, 82% stated that the enclosure period was a vital management measure, "for the fish to grow" (5 fishers), "for fish and shrimps to grow" (5), "for fish reproduction" (3), "for shrimps to grow" (1), or "to allow the fish to migrate from the estuary to the open sea" (1). Despite that, 75% of the fishermen acknowledged that they would fish during the enclosure period.

Despite awareness, the practice has not changed according to best practices for conservation management. Although they knew the law's content, e.g., the need for a license, the enclosure period, and the reasoning behind it, all interviewees stated that they fished during the enclosure period.

70% of the fishers had an opinion about who was responsible for implementing the enclosure period: most stated that it was the government (8 fishers), the Capitania or Coastal Authority (4), the Ministry of Fishing (3), the Fishery Direction (1), or the community council of fishers, i.e., the Community Fisheries Organization (1) out of 37 fishers interviewed.

7 Fishing Activity During the Enclosure Period

Based on our observations during the 2017–2018 enclosure period, we hardly saw any law enforcement officials prevent illegal shrimp fishing, in fact, only once or twice during the five months. About 200 fishing centers cover about 40 river estuaries in the Sofala Bank, making regulation activities costly and demanding. Although the law is based on scientific evidence, to avoid overfishing and support ecosystem resilience, enforcement appears impossible. The fishers also do not appear to obey the law, making the law ineffective.

When the prohibition period was decreed in January, changes were observed in the group's fishing activity at the Chuabo Dembe fishing center. Speaking with the owner to arrange the date to accompany the fishing activity, he said fishing would not happen in that month, respecting the enclosure period regulation. However, when we went to the estuary in the morning, three fishing nets were anchored, making full use of their fishing capacity.

When it was time to get the fish out of the nets, we noticed that the number of anchored nets dropped to two, and only one of the three fishers was present. The fish buyers took the two canoes instead of waiting on the bank as usual and collected the catch directly from the nets. On the bank, the fish were separated and stored in their containers. Furthermore, during the enclosure period, we observed other people responsible for organizing the fishing activities and negotiating with the fish buyers. Instead of the boat owner, this was done by a 17-year-old non-fisher.

Additionally, in January, we witnessed a lower yield from the catches compared to December. One morning, a catch comprised a mix of "buero buero" and penaeid shrimp of small sizes (less than 4 cm) and a few fish. In total, the young man asked for 190 mt (€2.15) for the entire catch.

During the enclosure period, the fishers changed the net terminology from chicocota to gillnets. They also corrected me when I called them chicocota, stating that that net was harmful. Chicocota was, in fact, used in all the estuaries that we examined. On one day, we observed about 32 chicocota and nine trawling nets, similar to the number of daily nets observed during the normal period.

8 Discussion

We investigated whether the fishery policy effectively protects the fish resources and simultaneously ensures peoples' basic needs. The case study results show that artisanal fishers operate all year round, not because of a lack of knowledge of the enclosure period's benefits, but because fishery is their primary food and income source. The policy contains no measures to address their food needs during the enclosure period. This challenge is not an isolated local problem but a national challenge (UNCTAD 2017) that also appears in other tropical areas, such as Madagascar, Tanzania, and Kenya (Cinner 2009).

The main problem with the current policy is that it does not address the challenge as a whole. It does not provide a substitute income for artisanal fishing communities and empower them to engage in sustainable conservation practices. Additionally, these management policies do not explicitly recognize that the effective conservation practices of artisanal fishers in the estuary benefit open sea fishing. Thus, the artisanal fishers do not have any motivation to comply with the enclosure period.

Open sea fishing and aquaculture

A well-known approach to reduce pressure in coastal ecosystems is to encourage and safely scale up the technological capacity of coastal fishing communities (FAO 2020a; Ministério das Pescas 2010), since it reduces the stress and pressure on estuaries, bays, and other key coastal ecosystems (FAO 2020b). However, this policy has not been implemented for more than a decade because both the government and the fishermen have faced economic and financial constraints (Ministério das Pescas, 2010).

In any case, such measures may not be enough to address future food security. As in most African countries, the fishers in the Sofala bank coastal areas rely on already overfished and declining resources (IIP 2018, 2016, 2015). Under the present circumstances, there is no driver to reach sustainability and regeneration of the fish resources. Everybody is allowed to fish, and moving fishing to the open sea can also result in overexploitation. Additionally, maintenance of motorized boats may be a challenge for artisanal fishers.

Aquaculture is another possible solution. It is estimated that there is 33 000 ha available along the long Mozambican coast. Shrimp has been pointed out as a good development opportunity since only 2.5% of the country's total shrimp production comes from this sector (FAO, 2004). There is pressure from the government to promote actions leading to fisheries and aquaculture development (Nhantumbo and Gaile 2020). Small (and medium-scale) fish farming may develop in Mozambique (Muhala et al. 2020), ensuring food security for local communities (Nhantumbo and Gaile 2020).

However, the solution may be costly and produce environmental (pollution) and ecosystem risks. Outbreaks of disease have challenged the development of aquaculture initiatives in Mozambique over the last decade. Since 2012, the country has diagnosed a highly mortal disease for shrimps (the white spot disease), which forced the three industrial farms to stop their production for years (RAF 2013) and contributed to reduced development of this activity. In 2020, a deadly virus was detected in all Mozambican industrial fish farms, posing a significant threat to the livelihoods of small-scale fish farmers and wild "tilapia" shrimp populations (Jansen et al. 2019). Thus, a legal framework seems necessary to effectively manage aquaculture fish populations' health and ensure the responsible development of aquaculture.

Agriculture as an alternative income

Most artisanal fishing communities are rural. Rural households have a great potential to develop agricultural productivity (FAO 2004). About 83% of the Mozambican labor force involved in agriculture, forestry, and fishing are women (IOF 2015).

However, in Chuabo Dembe, 100% of fishers are men, while women are involved in processing (e.g., drying fish) and selling catches at the market. Most houses have smaller agricultural plots behind the houses or near the villages, where they grow food crops, such as Cassava, for household supply.

Several initiatives are acknowledged to be essential to diversify the income of the coastal communities. The combination of subsistence food production with cash crops should be seen as an integral part of improving food security at the household level in some developing countries (Ferrão et al. 2018), particularly in Mozambique. The rural economy is potentially vulnerable to future environmental and economic risks. Here limited, and prevented, cash crops can function as adaptation actions which can create substantial salary and work opportunities (Ferrão et al. 2018).

Sisal (Agave sisalana), a cash crop naturally adapted to the East African climate, has a low demand for water and labor, is resilient to droughts, and could significantly revitalize cash crop agriculture in coastal areas. The plant produced vegetable fibers and was introduced in Mozambique in the 1940s, mainly to manufacture ropes, mats, carpets, and handicrafts. Presently, sisal can also produce polymer composites for various applications. These include geotextiles, building materials, automobiles, the packaging industry, and electrical industry (Saxena et al. 2011; Silva et al. 2008).

Change in sisal demands due to the increasing use of synthetic fibers has triggered a lack of interest and neglect of this activity. However, it could be revitalized by taking advantage of the existing production structure installed in the past in the country's central and northern regions (Galvão 2013). Sisal has the advantage of being a green material that consumes much less energy in production than synthetic fibers (Asim et al. 2017; Saxena et al. 2011). Mozambique produces about one thousand tons annually, being one of the top ten countries with the highest production worldwide, but could produce much more (FAO 2017). Additionally, East Africa has the best climate and conditions for sisal. The plant has not been affected by diseases like those experienced in Brazil (Abreu 2010).

Strengthening the interconnections between stakeholders (fishing sectors, governments, and donors).

There is a need for increased interconnection between the different stakeholders, including the three fishing sectors, because they seem to work independently from each other, with no mutual cooperation. Here, NGOs could play a key role since they now have a legal framework to intervene, according to the new community management approach of the fishing regulations (REPMAR 2020).

Historically, the tension between the industrial, semi-industrial, and artisanal sectors has increased because of declining fish stocks. Given that some environmental NGOs are assessing the ecosystem's weaknesses and trying to implement solutions, it should also be in their interests to improve the interconnectedness and cooperation between the fishing sectors.

In general, NGOs can improve socioeconomic security in local communities and address conservation of natural resources, e.g., improving compliance and promoting alternative practices.

The government recognizes all these socioeconomic and environmental challenges. However, to address those issues, insufficient budget availability has been

the key struggle at the national level to enforce compliance with policies and address local communities' needs to promote behavioral change.

Most of the ongoing fishing conservation projects rely on external funding and aid from local and international non-government organizations (NGOs) and civil society organizations (OCS), owing to the government's has budget deficiencies. NGO activities are based on external funding. They may focus primarily on donor interests or demands, which do not necessarily reflect local development needs for a long-term stable conservation approach.

The investments available seem to be very limited, and it seems that this will be even more limited in the future because of the COVID-19 pandemic. Public funds must be used in the best possible way, meaning that they address the real needs of both ecosystem conservation and fishing communities' wellbeing.

NGOs are an essential link between the artisanal fishing communities, national government, and potential donors. They should have closer contact with these communities' challenges to provide practically applicable long-term and sustainable solutions. This could also improve the transparency and equity of the way donor funds are processed locally (e.g., to avoid corruption). NGOs should be more engaged in understanding the local and cultural context (e.g., understanding the needs, the cultural reality, and expectations).

9 Conclusion and Future Outlook

Current shrimp fish policies aim at ensuring future food security through effective management measures that protect the regeneration and conservation of shrimp resources. The present analysis concludes that the Mozambican fishing law addresses an important shrimp management issue by establishing regulations—an enclosure period for both open sea and river fishing—essential to ensure shrimp reproduction. However, the law is not effective. Artisanal fishers know about the enclosure period but do not obey it. A key challenge is that artisanal fishing communities depend heavily on fishing and have no alternative food supply or income during the enclosure period.

It is argued that it would be possible to implement policies that integrate the sustainability of the rural fishing communities and the sustainability of the estuarine ecosystems that sustain Mozambique's fish resources. The participation of all stakeholders, namely local communities, government, the fishing industry, and NGOs, plays a crucial role in implementing such policies. The NGOs' role needs to be reassessed, taking into account the local populations' daily life challenges and mediating between the stakeholders since they represent a link between the government, donors, and communities. To implement the fishing law effectively, alternative income or food security must be provided for fishing communities during the enclosure period. Agriculture and production of climate-proof cash crops, such as sisal, a fiber-producing plant, is presented as an alternative income-generating activity. Subsistence agriculture is already routine in the fishing communities, making it easier

and more sustainable to upscale than aquaculture. Community-scale sisal plantations could be the key to effectively implementing food security during the enclosure period by providing extra income for the artisanal fishing communities. Further fieldwork is required to test the viability of this proposal at the local level.

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