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Fishery Characteristics and Management in the Floodplain Lakes of Tana River delta, Kenya

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Abstract
Tana River delta floodplain is maintained through a dynamic balance revolving around frequency, extent, and flooding duration. These seasonal and annual flooding variations strongly affect the floodplain communities' fisheries and livelihoods. In the delta, fishing is an important traditional source of livelihood, practiced alongside local agrarian livelihoods such as shifting cultivation and livestock keeping. Fishery utilization and management characteristics in the Tana River delta floodplain lakes are not well documented. This study investigated the characteristics and management of small-scale fisheries in the Tana River delta floodplain lakes. Information relating to past flooding events, fishery characteristics, prevailing regulatory regimes, and the impacts of seasonal flooding were collected using field observations. We collected the information at awareness workshops and key informant interviews between June and September 2018, which covers a significant flooding period of that year, and August 2021, a relatively dry period in the delta. We collected the information from communities living around floodplain lakes in Tarassa and Ngao in the southern part of the delta and Tamaso and Lango la Simba areas in the eastern part of the delta. Results indicate that fishery resources are more diverse during flooding (new species recruitment, presence of spawning, breeding, and foraging sites). The community does fishing all year round, and some part-time practice fishing to supplement shifting cultivation and dry season grazing that are greatly affected by periodic flooding. Floods were crucial in enriching floodplain lakes with diverse fish species. Women are involved in fish trading, acquiring fish primarily within their lineage. Fish is mainly sold in local markets due to poor preservation leading to low-value addition. This study recommends a comprehensive value chain analysis to improve it. Fishing communities around the villages are also most vulnerable to climate change because fishery resource governance needs strengthening, and most households are not involved in resource management. Besides, fishers have limited livelihood options due to lacking skills, technologies, and knowledge to undertake climate adaptation-related decisions. We recommend desilting floodplain lakes and improving connectivity with the main river channel. Additionally, an urgent need is to institute a co-management system to bring together different user groups around these floodplain lakes.
Keywords: Fisheries, Flooding, Livelihoods, Floodplain lakes, Governance, Tana River delta
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INTRODUCTION

Sub-Saharan Africa's extensive river floodplains cover approximately 30 million hectares of land with substantial agricultural potential (Hamerlynck *et al*., 2019). Alongside crop production and pastoralism, the fishery is a significant livelihood and economic activity on the floodplains. In River Rufiji's floodplains in eastern Tanzania, communities almost entirely derive their livelihood from flood-associated ecosystem goods and services (Turpie, 2000). These communities consider floods a blessing necessary to sustain floodplain fertility (Duvail & Hamerlynck, 2007).

In Kenya, the Tana River delta floodplain's high productivity is maintained through a dynamic balance around the frequency, extent, and duration of flooding (Leauthaud et al., 2013). These seasonal and inter-annual variations in flooding have intense effects on the deltaic communities' fisheries and livelihoods (Duvail *et al.*, 2017).

The seasonality of flooding in the Tana River delta affects the abundance and distribution of floodplain fisheries. Subsistence fishing is an essential livelihood and economic activity that ranks second only to shifting cultivation in the delta (Terer *et al.*, 2004). The delta fisheries resource has attracted local communities, especially the Pokomo, Orma, Wardei, and immigrant fishing communities, such as Luo and Luhya from Lake Victoria and Kenya's western regions. These communities practice small-scale fishing for domestic consumption and commercial purposes (Duvail *et al.*, 2012). However, fisheries resource has been shrinking partly because of poorly regulated fishing and growing demand due to local population growth. The local fisheries resource has also been overfished due to inappropriate fishing gear and growing demand for markets outside the delta. The declining fish resource has also been attributed to the natural processes resulting from reduced magnitude, duration, and extent

of flooding and increased siltation of floodplain lakes and depressions (Maingi & Marsh, 2002).

As a component of the renewable natural resources sector, fisheries play an important role in Kenya's national economy. The fisheries and aquaculture sector contributed about 0.8% to the Gross Domestic Product (GDP), providing direct employment opportunities to over 500,000 people and indirectly supporting over two million people (KMFRI, 2017). The sector supports about 2.3 million Kenyans involved mainly in fishing, fish processing, trade, micro-enterprises in associated industries, and ancillary activities. Besides, fish contributes to food and nutritional security (FAO, 2018), a source of protein consumed directly by small-scale fishers at the household level.

In pre-colonial Kenya, indigenous and local communities managed fisheries and access to water at the local level, where community user rights and negotiated agreements with neighbors were crucial for ensuring the sustainable use and preventing resource conflicts. After independence in 1963, the Kenyan government took over fisheries management, continuing the top-down approach implemented during colonial times to manage fisheries resources, which completely disenfranchised local custodians of the fishery resource.

Today, all capture fisheries in Kenya are managed by the Kenya Fisheries Service (Government of Kenya, 2016). In response to the decline in fish stocks and decreasing aquatic biodiversity, Kenya adopted co-management of fisheries resources by establishing community-based fisheries beach management units (BMUs). The aim was to integrate local and national management regimes and optimize the use of local knowledge and scientific evidence (FAO, 2018).

Despite fish being a vital food resource to all floodplain communities, fishery utilization and management characteristics in the Tana River delta floodplain lakes are not well documented. Further, studies have not been carried out on flooding in sustaining Tana delta floodplain fish biodiversity and fisheries. Therefore, this study aimed to determine the characteristics of the deltaic fisheries and how it was influenced by seasonal flooding and the existing regulatory regimes. The specific objectives were to investigate the seasonal flooding fishery resources, determine the fishery characteristics in the floodplain lakes, and interrogate the prevailing fishing regulatory regime in the Tana River delta.

STUDY AREA, MATERIALS, AND METHODS

Description of the study area

We carried out this study in the Tana River delta located in Tana River County, along the Indian Ocean coast of Kenya. The delta lies on latitude 02° 30´S and longitude 40° 20´E. It has an area of 130,000 ha, with its apex at Lake Bilisa in Garsen and its base covering a distance of 50 km along Ungwana Bay on the western shores of the Indian Ocean (Figure 1).

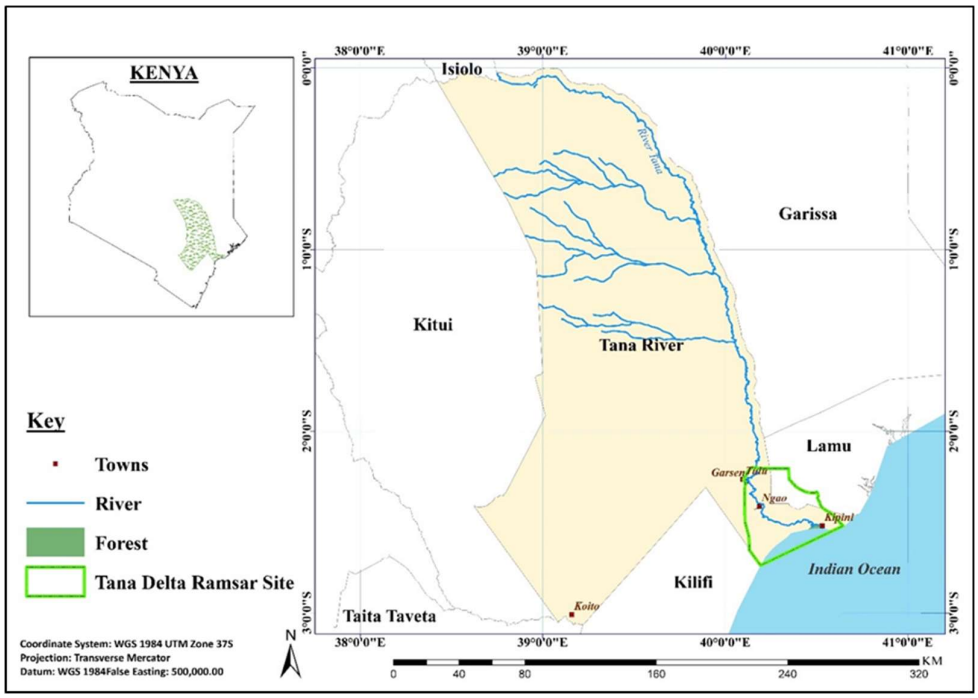

Figure 1: Map of Tana River County showing Tana delta Ramsar Site

At Garsen, the river divides into two major branches: Oda flows southwards, while Matomba flows eastwards towards the ocean. These two branches split further into tertiary branches, which form an extensive network of channels that inundate the delta during flooding. Tana Delta is generally sparsely populated, with an average density of six persons per km² (Government of Kenya, 2018). Further, the county integrated development plan indicated that the population growth rate was 2.8%, and 62.2% lived in absolute poverty. The study was carried out around four floodplain lakes in the delta's northwestern part (Figure 2). Three lakes, Gumba, Kongolola, and Dalu, were open-access fishing sites. Lake Shakababo was a restricted fishing site by the County Government of Tana River. The restriction was done after the introduction of tilapia fingerlings to boost the local fisheries. All four lakes had been dry for over a decade and only became flooded and reconnected with the main Tana River channel during the study period between 2018 and 2021.

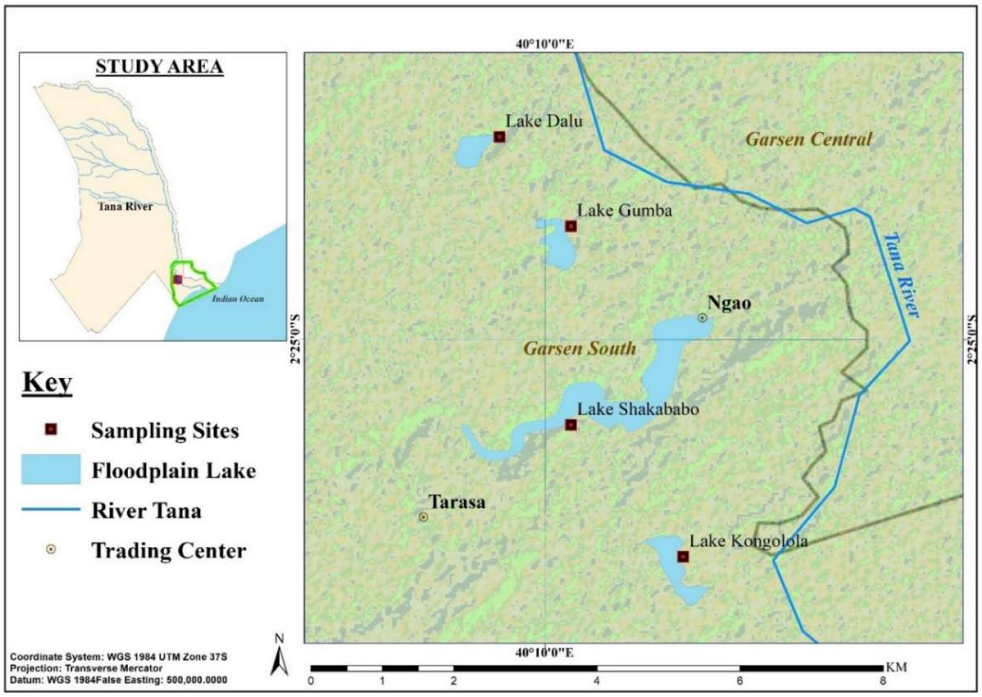

Figure 2: Garsen area showing the distribution of the study sites in the Tana River delta.

Materials and methods

Information on fishing patterns, flood dynamics, and fisheries governance was collected from June to September, covering the flooding event of 2018 and in August 2021, a relatively dry period in the delta. Interview schedules were prepared with structured and semi-structured questions to extract information from fishers. Interviewees were purposively selected because they engaged in fishing or fish vending regularly. The respondents included 29 fishermen and ten women fish vendors encountered while performing their everyday activities. We conducted the interviews in the Swahili language with the help of a trained research assistant. We also conducted focus group discussions (FGDs) comprising persons drawn from the fisheries marketing chain at Garsen. We also conducted key informant interviews (KIIs) comprising local fishers, traders, and County fisheries officers on the shoreline of the floodplain lakes to secure consensus and validate the fishermen and fish vendors' responses. The principle of informed consent was given the required attention by explaining the purpose of the study to participants and making them aware that participation and answering any questions were optional. Further, we disclosed none of the information provided by the interviewees to other people. The questions asked were filtered to address contentious issues relating to the wetland fishery: fishing patterns, flood dynamics, fishing gear, and fisheries governance and climate adaptation technologies in the River Tana delta.

Data Analysis

We analyzed qualitative data by collating responses into themes relating to fishing patterns, flood dynamics, fishing gear used, fishers' adaptation technologies to climate change, and fisheries governance. We converted the quantitative responses from individuals into frequencies, which we later explored using descriptive statistics.

RESULTS AND DISCUSSION

Flooding events in the Tana delta during the last two decades

The flooding of April – June 2018 was a significant event in the preceding decades since 1992 (Figure 3). The flooding is comparable only to the El Niño flooding of 1997 to 1998 in post-hydroelectric dam construction in the Tana Rivers' catchment (Maingi & Marsh, 2002). Local communities reported that peak flows and subsequent increases in sediment loads during 1997-1998 flooding led to the re-emergence of lakes such as Lakes Moa, Shakababo, Bilisa Boka, and several other channels. As a result of prolonged drought, all floodplain lakes completely dried up in 2010 except Lake Moa in the eastern part of the floodplain.

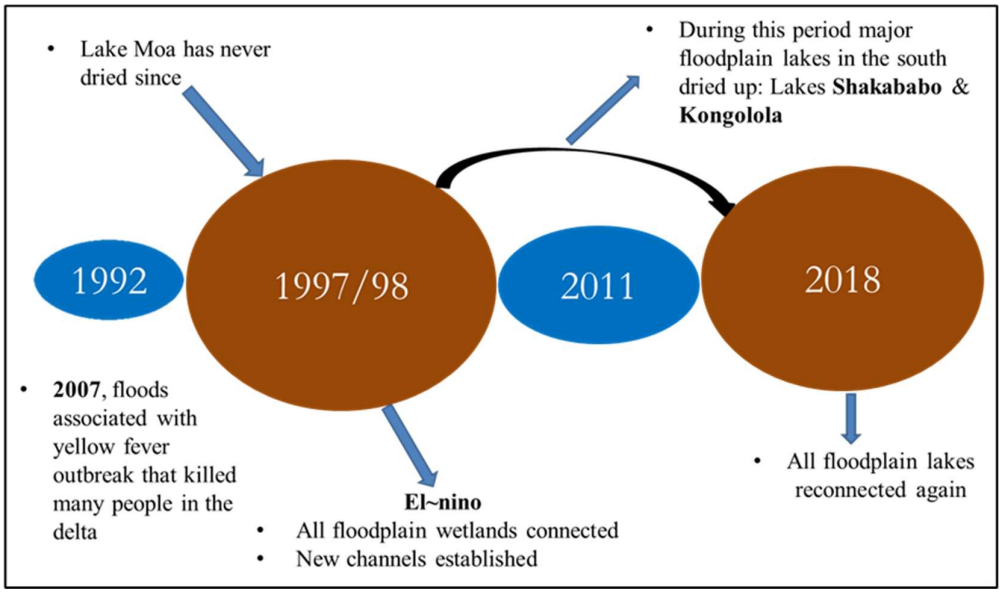

Figure 3: Major flooding events in the Tana River delta during the last two decades.

The four lakes targeted in this study receive floodwater from the Oda channel in April-June long rains and October-November short rains. Surface runoff due to local rains in the immediate catchment accounted for a small portion of the water flowing into the lakes. In most years, floods were experienced in the delta towards the end of April and at the beginning of May. Lake Shakababo, the largest among the four lakes, was connected to the Oda channel via the Kisiki brook. Fishers interviewed around this lake stated that the lake had dried entirely in 2010. They cited a human-made diversion in 2008 that diverted water to the Matomba channel on the North East of the delta. However, they did not seem to agree on what caused the diversion; siltation was widely mentioned to have caused the river to divert, and others believed commercial farmers intentionally diverted the river watercourse to pass through Matomba. The natural embankment along the Oda branch was high, estimated to be over three meters. Thus, a substantially high water level was needed before the surrounding floodplains could be inundated.

Table 1: Distribution of fisherfolk in the study sites located in the Tana delta

Variable	Category	Number of respondents	% Frequency
Fishing site	Lake Shakababo	13	41
	Lake Gumba	9	28
	Lake Dalu	2	6
	Lake Kongolola	8	25
	Total	**32**	**100**

Table 2: Social demographic characteristics of the targeted fisherfolk in the Tana Delta.

Characteristic	Category	Number of respondents	Relative frequency
Gender	Male	31	81
	Female	8	19
Age	< 24 years	9	21
	> 24 years	30	79
Marital status	Married	25	63
	Divorced	9	24
	Unmarried	5	13
Fishing cycle	All year round	21	54
	Seasonal	18	46

Table 3: Common fish species identified by fishers

Local name	English name	Scientific name
Borode/Chika	Gregori's Labeo	*Labeo gregorii*
Ngogo/Korokoro	East coast/Tana squeaker	*Synodontis sp.*
Pawa	Silver Catfish	*Schilbe intermedius*
Parapara/Ntuku	Tilapia	*Oreochromis spilurus*
Tonzi	Sharp-tooth catfish	*Clarias gariepinus*
Mpumi	Wide-headed catfish	*Clarotes laticeps*
Mpumi hwahwa	Somalian giant catfish	*Pardiglanis tarabini*
Mchokole/Njumburi	Tank goby	*Glossogobius giuris*
Kamongo	Lungfish	*Protopterus sp.*
Mbelewele	Tana Bulldog	*Marcusenius devosi*
Kwakwa	Red-fin robber	*Brycinus sp.*

Socio-demographic characteristics of the fishers

A total of 39 respondents engaged in fishing or fish marketing were interviewed. Most of the respondents were found around Lake Shakababo in Tarassa (41%), followed by Lake Gumba in the Ngao area (28%) and Kongolola (25%), as shown in Table 1. Lake Dalu, which was invaded by dense shrubs of *Prosopis juliflora*, hindered boat access during the study period. The local communities reported that in this lake, fishing is difficult due to competition with large flocks of piscivorous birds, particularly Yellow-billed Stork (*Mycteria ibis*) and White-breasted Cormorants (*Phalacrocorax lucidus*). Fishing opportunities were, therefore, limited.

Out of all the respondents interviewed in all study sites between June 2018, February 2019, and August 2021, 81% were men, while 19% were women (Table 2). Most respondents (79%) were over 24 years old, with the rest being adolescents working alongside adult men and women. School-going children were actively fishing alongside adult fishers during the school holidays.

Although the majority of the respondents (63%) were married, a significant proportion of them (37%), especially women, are single either because they had been divorced (24%) by their former husbands or had not decided to get married (Table 2). This situation was replicated in all fish landing beaches in the studied floodplain lakes in the Tana delta.

The study shows that fishing is a full-time livelihood activity for 54% of the respondents interviewed in the studied floodplain lakes of the Tana delta (Table 2). However, 44% of the respondents indicated that they were engaged in fishing on a seasonal basis, incredibly shortly after the floods when fish were perceived to be abundant in the floodplain lakes. However, small-scale fishing continued to meet household protein needs until the floodplain lakes dried out.

Men mainly carried out fishing activities (81%), while women were primarily engaged in the fish collection from the landing beaches, weighing, processing, and marketing. However, women fished with basket traps or scooped fish with baskets and buckets in shallow water, where it was challenging to use fishing nets. Some women fish vendors contracted men to fish for them, and some owned their boats and fishing nets. Thus, women engaged in fishing activities indirectly, partly because their involvement is forbidden by customary regulations, as explained by fishermen found fishing or repairing nets at the beach. However, women were custodians of some money from selling their husband's fish catch.

Fish marketing chain

While some women fish vendors bought fish directly from fishers at the landing site, most said they received fish from their fishing husbands. They also indicated that most women fish vendors provided income for their families. The women traders located potential fish-buying sites through telephone calls with the male fishers to inquire about fish availability. Interviews with the women fish traders also revealed personal relationships with individual

fishers supplying fish. One woman described how most of them were lured into sexual relationships to be assured of fish supply. However, fishers seemed not to concur; they said they had to maintain a reliable fish vendor who could collect fish on time due to a lack of storage facilities. Some fishermen also reported exploitation from women fish vendors; they said women would indirectly coerce them to sell fish at lower prices in exchange for sexual favors.

Fishery patterns and influence of seasonal floods

Fishing in the Tana River's lower floodplains is an essential source of livelihood for the deltaic communities. Fishing was majorly (54%) carried out all year round and on a seasonal basis (46%) (Table 2). Those who practiced seasonal fishing did so to supplement other livelihood activities such as farming and livestock rearing. The majority took up fishing when it flooded to take advantage of the abundant fish and cover for the other livelihood sources untenable. Similar trends in fisheries utilization have been reported in the Upper Zambezi floodplains (Abbott et al., 2007).

Fishers believe that fish breeding season started at the onset of long rains in April - June. They explained that fish spawning and feeding continued as floodwater rose in June - August. Once the river overflowed and inundated the floodplain, juveniles colonized the flooded grasslands for food and shelter. Also, some fishers said that adult fish tended to forage along the main river. As the floodwater receded from August through September 2018, the widely dispersed fish in the floodplain started returning to the main river channel. Most fish remain confined in isolated pools due to lost connectivity, where intensive feeding, faster growth, and higher mortality due to bird predation and degraded water quality ensue.

Fishers interviewed stated that fishing was more profitable during the dry season in January – April. During this period, fishing activities were confined along River Tana's main channel and permanent floodplain water bodies such as Lake Moa. During the focus group discussion at Tarassa, it was found that floods created diverse habitats in the delta that consequently attract different fish species (Table 3). Besides, fisheries activities were said to vary with location and season. Experienced fishers fishing for commercial purposes mentioned they were willing to invest in appropriate fishing gear to supply fish throughout the year. Some mentioned they went as far as the Kipini estuary and into the Indian Ocean to fish until the river level rose again. A seasoned fisherman at Lake Shakababo indicated that women and children joined in fishing at peak flooding using gears, including makeshift forms, such as buckets to scoop fish in isolated pools.

Fishery characteristics

a) Fishing gear

Active gill netting and seine net fishing (Figure 4) were predominantly used when water levels in the floodplain lakes were low. Fishers explained that benthic-dwelling fish such as *Protopterus sp.*, *Clarotes laticeps*, and *Clarias gariepinus* were caught using baited hook and line. Subsistence fishers explained that, as the river water spilled laterally into the floodplain, they started using traditional fishing methods and indigenous knowledge more frequently (Table 4).

Table 4: Summary of various traditional fishing methods in Tana Delta floodplains

Gear type	Mode of operation	Target species	User	Period
Dragnet (Fig. 18a)	Active	Gregori's Labeo; Silver Catfish; Tilapia; Red-fin robber	Men	Pre-flood Post-flood
Basket trap 'Mgono' (Fig. 18b)	Passive/Barrier gear when water is moving	Sharp-tooth catfish; Lungfish	Men	During flood
Gillnet	Passive	All	Men	During flood Post-flood
Spear	Active	Sharp-tooth catfish; Lungfish; Wide-headed catfish; Somalian giant catfish	Men	Pre-flood
Hook and line	Active; Passive on some occasions	Sharp-tooth catfish; Lungfish; Wide-headed catfish; Somalian giant catfish; large Tilapia	Men	All-time
Mosquito net	Active	All fish trapped in farmland water pools.	Women	During flood
Scoop buckets	Active	Trapped fish	Women & Men	All-time

Though not mentioned by fishers interviewed for fear of victimization, mosquito nets were widely used for fishing in June – July when the floodplains and farm areas were inundated. Fishers mentioned that active gill netting became more profitable when floodwater increased. However, they said there were higher risks of gear being washed away by the increasing waters. Others said that during flood peaks in May – July, the fish catch was low as fish were dispersed, and water speed was high then. This high water period is also a period locals identified as “Kusi," the Southeast monsoon season, between June to September, is when fish are said to be actively spawning.

Figure 4: Fishermen using a beach seine at Lake Gumba

Figure 5: Selection of fish sold along the shores of Lake Gumba: Sabaki tilapia *Oreochromis spilurus* (L) and African sharp tooth catfish *Clarias gariepinus* (R)

Fish value chain

Most fish traders were women, while men almost exclusively did fishing. At the focus group discussion, some women indicated that they own fishing nets and contract fishers to do the fishing for them. In some instances of a fishing couple, the husband did the fishing while his wife processed and took the fish to markets. During field visits, it was observed that fish was sold fresh or dried by smoking before selling. During this study, most fresh fish were sold at nearby markets such as Garsen and Minjila. Fishers drying their fish targeted traders from distant markets like Malindi, Takaungu, and Kilifi, where dried fish prices were said to be better.

At the focus group discussion, women fish vendors indicated that they travel from village to village sourcing for the dried fish. Some fishermen who doubled as fish vendors would sell their catch at nearby markets. Fish was sold in bunches around the floodplain lakes (Figure 5), and the price of each bunch varied with species type, size, and season. For example, at the time of this study, a bunch of fresh *Clarias sp.* was sold at approximately KES 100 (US$1) and a bunch of Sabaki Tilapia at KES 50 (US$ 0.5) at a fish landing site. Very few women fish vendors

had cold storage boxes to transport the fresh fish to markets. As such, motorbikes were deemed helpful for quickly delivering fresh fish to nearby markets.

Several reasons could explain the success of women in fish trading. Women traders have become more innovative in ways of sustaining their fisheries activities. One such means is through informal cooperative movements locally known as 'chamas' that provide financial support. Perhaps, more research on the role of women in floodplain fisheries is needed to adequately evaluate their contribution to a sustainable blue economy (FAO, 2018).

Fisheries management around the floodplain lakes

a) Existing governance structures

Most fishers interviewed reported that access to fishing sites was less restricted during floods. Nevertheless, it appeared this was linked to the inaccessibility of floodplain rather than regulation, as indicated by one fisherman:

> No one has control over fishing grounds, although farmers restrict some areas. When the delta floods and fish migrate to floodplain lakes, no one stops us from fishing. All roads are broken, and we can no longer access important fishing zones.

Some respondent fishers, however, explained attempts by some village groups to restrict access to neighboring lakes. A headman in Gumba village narrated how he mobilized village members to dig up a dyke that released floodwater from the nearby Oda channel into Lake Gumba. He explained that Lake Gumba had lost connectivity almost a decade ago when Oda brook started receiving less water. Once they dug up the channel, the lake filled with water and became rich in fish. Consequently, only village members had privileged access to fish at the lake, perhaps indicating they owned it then. Therefore, the lake seemed to be locally governed, and outsider fishers were supposed to seek clearance from Gumba village headman though this was not strictly adhered to. However, the duration of control was tied to seasonal flooding and specifically to fisheries activities.

At the start of this study in June 2018, the County Government of Tana River (CGTR) facilitated the digging up of Kisiki brook, enabling yet another important and the largest floodplain lake in the southern delta, Lake Shakababo, to fill with floodwater. The county department of fisheries then stocked the lake with Tilapia fry to enrich its fisheries. CGTR then implemented a four-month closed season around the lake, reopening it to active fishing activities in October later that year. Most fishers interviewed around the lake criticized the lake's prolonged closure, saying that should another flooding occur in November as expected, the adult fish would have easily migrated back to the main channel. Some fishermen interviewed indicated that the village scouts employed to enforce the closure were using the motorboat provided to fish at night and selling the fish to far markets. Others said it was an uninformed decision when most of the deltaic community relied on food aid and fishing as the most immediate source of livelihood at that time. Despite the management intervention by CGTR, local community members were actively exploring possibilities of reviving Lake Shakababo Beach Management Unit, which collapsed in 2008 when the lake completely dried. Many agreed that managing the lake as a community resource was better for its sustainability.

While the intentions of CGTR seemed genuine, they overlooked an important aspect of managing community resources. The local community's involvement enhances a strong sense of ownership and commitment to the sustainable management of resources. At the time of this study, local fishers and other lake users were mulling, forming a Beach Management Unit (BMU) around Lake Shakababo, which further reinforces their intention to manage the lake by themselves. The Food and Agricultural Organization (FAO) has recommended community-based natural resource management to curb the over-exploitation of small-scale fisheries resources and improve governance (FAO, 2018)

Kongolola and Dalu floodplain lakes were entirely open access. However, they had minimal fishing activities. Local conditions around these lakes have imposed inadvertent fisheries governance. For example, *Prosopis juliflora*, commonly known as "Mathenge," prevented fishing activities across the floodplain while offering important fish breeding and spawning sites. Around Lake Kongolola, most residents were farmers and therefore were less involved in fishing activities. There were no operational Beach Management Units around the study floodplain lakes. This was attributed to the lack of significant flooding in the delta for over a decade. The drought led to the drying of all floodplain lakes in the area.

b) Traditional mechanisms of fisheries resource governance

Many fishers could not expressly describe existing traditional methods in fisheries governance. However, a discussion with an elderly fisher at Lake Shakababo revealed some traditional regulations in the last four decades. There were temporal fishing restrictions to certain areas of the lake around June. It was known that these were fish spawning and breeding areas. Further, some lakes on the broader delta had a fishing access restriction. For example, a fisher from the Tarasaa area to the west of the delta would first seek permission from the village headman to fish at Lake Shakababo.

An interview with another fisher at Lake Gumba indicated that some gear types were restricted during certain seasons. For instance, seine nets and gillnets of below one inch were discouraged in all fishing sites. Also, there

were agreements on the number of seine nets drawn at a lake daily. This, as explained by one fisher, was to reduce the overexploitation of the fishery resource. However, these agreements were frequently flouted; the rapidly shrinking lake and many waterbirds meant competition for the readily available fish.

Nevertheless, it seemed that knowledge of traditional fisheries governance methods depended on the fishers' age and tribe. Fishers from the traditional fishing communities in the delta, Luo, Luhya, and Pokomo, were more conversant with these methods. Similarly, the elderly fishers could explain these traditional methods that had since been abandoned in favor of BMUs. Alluding to this, a fisherman in the Tamaso area on the eastern side of the river, upstream of the delta, mentioned that most current fishers were a young generation that took up fishing after the last El Nino flooding event in 1997-1998. They may have yet to be aware of the traditional methods of regulating fishing activities in the delta.

c) Formal governance

Formal governance was predominant and was conducted by the Kenya Fisheries Service (KeFS), County Department of Fisheries, and Beach Management Units. In the Tana River delta, a sub-county fisheries officer represented the Tana River County Director of Fisheries. A fisheries officer based at the Minjila trading center was the Kenya Fisheries Service (KeFS) representative within the study area. The fisheries officer had an overall fisheries management mandate in Tarasaa and Garsen wards. During an interview with the fisheries officer in June 2018, the role of ward fisheries officers in fisheries management and development was elaborated. Overall, they were responsible for monitoring, control and surveillance and fish marketing and distribution. Still, the officers were responsible for compiling reports submitted to the sub-county fisheries officer monthly.

The data captured in the report included: fish landings; fish marketing and distribution; events, incidences, and occurrences; staff matters; and challenges and constraints. When asked about the role of floods in sustaining fish resources in the delta, the officer agreed that floods are important in replenishing floodplain lakes with fish. However, it took much work to quantify the fish harvested during that period since many areas became inaccessible during floods. Considerable effort has gone into establishing adaptive strategies, such as delineating critical fishing zones and forming BMUs at every fish landing site (Government of Kenya, 2016). While this is true, operationalizing such mechanisms in the studied floodplain lakes had been difficult due to the lakes' seasonality.

Moreover, locals used diverse methods (Table 3), most traditional systems that were not regulated, and the extended dry periods in the recent past, coupled with almost no major flooding, led to an extensive shift in livelihood systems in the floodplains. In this regard, fishery resource exploitation is the immediate alternative to augment dwindling fortunes from farming activities and livestock production. As a result, increased commercialization of fishery due to increasing demand was reported. More effort in monitoring and surveillance was therefore needed.

Fishers' adaptation knowledge, skills, and technologies to climate change

Fishing villages in the Tana delta are in isolated areas with few alternative employment opportunities. Most fishers interviewed reported diversification of livelihoods, either as a coping (short-term) strategy or an adapting strategy (long-term). Alternative livelihood activities involve activities such as farming, both farming and livestock herding. For instance, fishers around Lake Shakababo mentioned switching between rice farming, fishing, or seasonal migration as a response to the variability of catch and fishing closure imposed by the County Government. However, for traditional fishers, diversification was seen to be one of the coping strategies to deal with vulnerability for self-consumption purposes only, as fishing remains the only activity that generates income. For them, stopping fishing and making a living on land is not a livelihood option.

Fishing households in Tana Delta only possess more than a small cottage, a small piece of agricultural land for cultivation, and a small amount of livestock. Livestock is not commercially exploited but serves as security in times of scarcity. Moreover, agriculture is rendered difficult by persistent drought and the proliferation of the 'Mathenge' tree. Agriculture could have been an alternative option to climate change for fishers, but this activity is also susceptible to climate change. Slash-and-burn agriculture, which is not sustainable, is the prevailing method employed. A few fishers have adopted alternative and stable income-generating activities. These include poultry farming, beekeeping, and handicrafts.

Fisheries conflict resolution mechanisms

Conflicts relating to access to fishing zones were said to be more intense during the dry season. It was reported that some fisheries conflicts were indirectly aimed at protecting boundaries. For instance, a fisherman at Lake Gumba said that they were not comfortable with some pastoralists who had camped next to the lake with large herds of sheep and goats since it was refilled with water. This was viewed as an indirect attempt to take over the lake, denying them an important fishing site. Conflicts relating to incursion by experienced non-local fishers were also mentioned. During prolonged drought, fishers migrated to various delta parts to access important fishing sites. Usually, the migrating fishers possessed better fishing gear and were more versed in fish behavior.

In most cases, local fishers were prepared to protect their fishing sites and occasionally confiscated intruders'

fishing gear. An interview with a village headman around Lake Shakababo revealed that fisheries had experienced few conflicts contrary to other livelihoods in the area. Although there were conflicting interests in controlling fishing sites, this had always been kept lower due to the seasonality of floodplain lakes. Furthermore, fishers migrated once the lakes dried, leaving farmers and pastoralists to utilize the land.

Conflicts were reported to village headmen. The headmen and other elders would then arbitrate and solve the issue. In some instances, the cases were reported to local administrators such as the sub-chief and chief. Elsewhere, around Lake Moa, the local Beach Management Unit was actively handling all issues relating to fisheries governance and conflict resolution.

CONCLUSION

The current study covered fish landing sites around floodplain lakes in Tarassa and Ngao in the southern part of the delta and Tamaso and Lango la Simba areas in the eastern part of the delta. 39 fishers, including 29 fishermen and ten women fish vendors, were interviewed. Floods were responsible for fish recruitment into the floodplain lakes like in any other floodplain fishery. The abundant and multispecies nature of floodplain fisheries was exploited using different gears for subsistence and commercial purposes. Women dominated the post-harvest fish value chain, acquiring fish primarily based on community family lines. The fish value chain needed to be developed, characterized by a lack of storage facilities and uncertainty in supply due to infrequent flooding in the area. Fishing communities diversify their livelihoods to cope and adapt to climate change. The skills, technologies, and knowledge need to be enhanced to widen their options of livelihoods. The floodplain lakes were being managed through community user rights; these were less adhered to due to the lakes' seasonality.

This study recommends;

- Desilting of floodplain lakes and improving connectivity with the main river channel.
- Instituting a co-management system to bring together different user groups around these floodplain lakes.
- Comprehensive value chain analysis of floodplain fisheries

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