ASSESSMENT OF FISHERS' CATCHES ON A KAVANGO RIVER FLOODPLAIN, NAMIBIA

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ABSTRACT

Floodplains in the Kavango River sustain an important fishery that provides riparian communities with a source of food, seasonal employment and income for those that sell their catches. This study was conducted to investigate the effort, fishing gear, and fish catches of the fishers on the Kamutjonga floodplain along the Kavango River, Namibia. Fishers were monitored daily for two annual flood cycles of 2018 and 2020 (February to June). A total of 254 and 462 fisher days were recorded during the 2018 and 2020 flood cycles, respectively, where females dominated the fishing in both years. In 2018, the catch per unit effort (CPUE) in number (fish/set) (set = 60 min) were highest for mosquito nets (93 fish/set) followed by plastic containers (12 fish/set), hook and line (10 fish/set), and traditional traps (7 fish/set). In 2018, CPUE in weight (kg/set) was also highest for mosquito nets (0.21 kg/set), but followed by hook and line (0.17 kg/set), traditional traps (0.03 kg/set), and plastic containers (0.02 kg/set). In 2020, the CPUE in numbers was the highest in mosquito nets (275 fish/set), followed by hook and line (18 fish/set), plastic containers (10 fish/set) and traditional traps (7 fish/set). In 2020, CPUE in weight (kg/set) was the highest in mosquito nets (0.73 kg/set) followed by hook and line (0.63 kg/set), traditional trap (0.06 kg/set) and plastic containers (0.03kg/set). In 2018, a total of 27 fish species were caught and the five most important species according to the index of relative importance (%IRI) were *Oreochromis andersonii* (79.6%), *Coptodon rendalli* (9.9%), *Pseudocrenilabrus philander* (3.8%), *Hydrocynus vittatus* (2.3%) and *Serranochromis angusticeps* (1.4%). In 2020, 23 fish species were caught on the and the five most important species according to %IRI were *Oreochromis andersonii* (65.5%), *Coptodon* *rendalli* (29.9%), *Hydrocynus vittatus* (1.8%), *Serranochromis macrocephalus* (0.9%) and *Pharyngochromis acuticeps* (0.7%). In 2018, the estimated catch was 150.53 kg constituiting of 79.00 kg during the rising phase, 68.49 kg during the receding phase and 2.99 kg during the high phase. In 2020, the estimated catch was 1 607.00 kg constituiting of 415.25 kg during the rising phase, 1 215.01 kg during the high phase and during the 123.65 kg receding phase. Most of the fish species caught on the floodplain were juvenile of larger fish species, while other fish species were from small sized fish species. It is suggested that harvesting of juvenile fish contributes to food security of riparian communities. The continuous monitoring of the exploitation partterns of the Kamutjonga floodplain is encouraged to enusure that managers are timely informed of any changes in fishing activities that might negatively impact the fish stocks and make management recommendation.

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Declaration

I, Deon Cain Tiyeho, hereby declare that this study is my own work and is a true reflection of my research, and that this work, or any part thereof has not been submitted for a degree in any other institution.

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1 Introduction

1.1 General introduction

Freshwater is probably the most important resource on earth as nearly all life depends on it (Hitt et al., 2015). Most of the earth's freshwater resources are in the form of ice glaciers, and polar ice constitutes 68.7%, together with underground water, which constitutes 29.9% (Shiklomanov, 1998). Only about 0.01% of freshwater is surface water, covering 0.8% of the earth's surface (Dudgeon et al., 2006). This small proportion of surface freshwater provides habitats to a remarkable diversity of fauna and flora, and about 100 000 of 1.75 million species live within the freshwater ecosystem, which equates to nearly 10% of the global species (Dudgeon et al., 2006).

Freshwater further provide important ecological services to those living on land, including wildlife and humans, therefore "water is life" (Arthington et al., 2010). Freshwater ecosystems provide goods and services which are critical to human development (Litschauer et al., 2018). Globally, freshwater is an important driver in food products such as crop production and pastoral animal husbandry together with aquaculture and freshwater fisheries (referred to as inland capture fisheries) (Arthington et al., 2010).

The freshwater biodiversity are however threatened by anthropogenic activities and environmental changes that degrade and destruct the natural functionality of the ecosystems (Litschauer et al., 2018). The threats include overexploitation, water pollution, flow modification, destruction or degradation of habitats and invasion of exotic species (Arthington et al., 2004; Dudgeon et al., 2006; Matthews, 2016). These threats have resulted in the decline of freshwater biodiversity, which is far greater compared to the terrestrial ecosystem (Vaughn, 2010). These threats when coupled with rising populations and climate change, result in increased pressures and demand on the freshwater ecosystem and related ecosystem services (Matthews, 2016).

Inland capture fisheries involves extracting mostly fish, but includes other living aquatic organisms such as crayfish, from inland water ecosystems (Welcomme et al., 2010). Inland waters in this respect consists of lakes, rivers and floodplain, marshes, swamps, streams, pond and water caves (Finlayson & D'Cruz, 2006). These inland water systems provide habitat to a large diversity of fish species, about 45% of the world's known fish species live in inland waters, amounting to about 10 000 identified fish species (Boltz et al., 2015). Fisheries from inland waters provides food security, source of income, employment, recreation, religious and cultural identity, and livelihoods to millions of people worldwide (Roos, 2016).

1.1.1 Global trends in inland capture fisheries and fish consumption

Over the years, inland captured fisheries have shown a steady growth of about 2.4 % since 1950 (FAO, 2020). In 2018, global inland catches were estimated to be about 12 million tonnes, the highest level recorded, representing 12.6% of the total capture fisheries production (FAO, 2020). It is important to note that some of these increases may not necessarily be due to increased catches, but due to improved reporting and assessment at country level (Cooke et al., 2016; Funge-Smith & Bennett, 2019).

The increase in human population attributes to the increase in inland fish catches as a result of an increased demand for food (Tran et al., 2019). According to Welcomme et al., (2010) "Demand is the primary driver of almost any activity, including fisheries". For instance, between 2008 and 2013, the world's population increased with an annual growth of 1.2% from 6.7 billion to 7.1 billion, and consequently resulted in increased fish consumption from 121 million tonnes to 140 million tonnes worldwide, of which

40% of the increase was linked to population growth (Cai & Leung, 2017). In 2018, global fish consumption reached 20 kg/capita/year an increase from 9kg/capita/year in 1961 to 20.5 kg/capita/year in 2018, and global fish consumption continues to grow at an average rate of 3.1 % from 1961 to 2017 and annual population of 1.6 % for the same period (FAO, 2020). According to Funge-Smith & Bennett (2019) the global fish consumption is expected to increase to 22 kg/capita/year by 2024.

1.1.2 Food security and nutritional benefits of inland fish

In recent years, there has been an increase in recognition of fish's nutritional and health benefits for humans, which may have resulted in the increase in fish consumption worldwide (Cai & Leung, 2017). Fish are highly nutritious as they contain quality protein, fat with essential fatty acids, vitamins and critical micronutrient such as calcium, iron, zinc and vitamin A, essential for the functioning of the human body (Roos, 2016). Inland fish resource provides nutritional fish in a manner that is affordable and easily accessible (FAO, 2016; Funge-Smith, 2018), and subsequently contributes to improved diets and nutrition in food insecure populations. Inland fisheries, when managed sustainably, could promote food and nutritional security at local and regional levels, especially in developing countries (Youn et al., 2014). Consumption of inland fish is significant as it provides important nutrients that contribute to alleviating undernourishment while encouraging growth and development and maintenance of the tissues and cells in human bodies (Kawarazuka & Béné, 2011).

1.1.3 Inland fisheries in Africa

The inland water bodies in Africa encompasses a variety of aquatic habitats such as lakes, rivers and their associated floodplains and swamps that contain large fisheries resources (Neiland et al., 2005). Inland fisheries contribute significantly to household food and nutritional security in Africa, where the world's most marginalized communities are found (Mosepele, 2016). In 2018, approximately 3 million tonnes of fish were reported from Africa's inland waters, representing 25% of the world's inland captured fish (FAO, 2020). About 77% of Africa's population live in close proximity to the water resources and obtain part of their livelihood from fish resources (FAO, 2019).

In Africa, most of the people who engage in fishing activities together with their families, with few exceptions, live at the margin of subsistence and human dignity, and engaging in inland fisheries provides means of subsistence in their lives as they are readily available and accessible (Bene et al., 2003). Inland fisheries mostly operate in the nature of open access, where there is little to no restriction and permission required by fishers to exploit the fish resource (Welcomme and Lymer, 2012). Inland fish and fish products are also readily available throughout the year in Africa mainly because of the wide distribution of inland water resources (Neiland et al., 2005). The nature of open access and availability of fish resource acts as a safety net attracting large numbers of people, especially those with little means of subsistence, access to the inland fish as a source of food (Bene et al., 2003). The availability of inland fish, coupled with the nutritional benefits of fish to humans exacerbate poverty and health deficiency in Africa, promoting food and nutritional security (Tran et al., 2019).

Despite the food and nutritional benefits, inland fisheries are not often a priority in the national and international policy discussion and governance. As a result, they are often overshadowed and overlooked compared to the marine fisheries (Cooke et al., 2016; Funge-Smith & Bennett, 2019). In 2011, the fisheries sector as a whole contributed U$ 24 billion to the GDP of all African countries, and the marine fisheries sector contributed an estimate of 14.9 billion (0.79%), while the inland fisheries sector contributed about U$ 6.2 billion (0.33%) (De Graaf & Garibaldi, 2015). Inland fisheries trail behind marine fisheries resulting in inland fisheries being undervalued and unappreciated and receiving little attention from governments and international aid organisations (Turpie, 2008).

Several authors suggest that the economic value of inland fisheries is undervalued due to inland catch not being reported properly (FAO, 2020; FAO and World Fish Center, 2008; Funge-Smith & Bennett, 2019; Lynch et al., 2016; Sandlund & Tvedten, 1992). FAO (2020) suggests that if the unreported inland catch were to be included in the valuation, the value of inland fisheries would increase to USD 38.58 billion. Usually, the statistics on the economic contribution of inland capture fisheries are inadequate, mainly because inland fish are traded locally and consumed directly by fishers and their families (Lynch et al., 2016). The importance of inland fisheries is considered mainly for subsistence food and income rather than contributing significantly to national economies (Turpie, 2008).

In terms of employment, about 5 million people are employed in the sector of inland capture fisheries (De Graaf & Garibaldi, 2014). Approximately 2.7 million people are directly involved in fishing activities, and 2.1 million are further involved in the post-harvest sector (De Graaf & Garibaldi, 2014). The post-harvest sector includes processing, transport, marketing and production as well as maintenance of boats and gear, and an estimated five people are linked to the value chain for each inland fisher (Turpie, 2008).

1.1.4 Inland fisheries in southern Africa

Southern Africa is home to a series of rivers and reseviour in Africa, which include the Zambezi system, Lake Kariba and Cahora Bassa, Okavango river and other rivers (Welcomme and Lymer, 2012). A large number of the human population turn to exploit the fish resource in inland waters to sustain their livelihood (AU-IBAR), 2012). Inland fisheries provides an important source of food, income and employment to many communities within the region (Welcomme and Lymer, 2012). In 2015, Mozambique and Zambia each landed approximately 80 000 tonnes, Angola, Zimbabwe and Namibia landed 38 514, 10 500 and 2 800, respectively, while South Africa, Botswana, Eswatini and Lesotho combined landed less than 1 000 tonnes (Table 1) (Funge-Smith, 2018).

Table 1: Inland fisheries statistics in southern Africa for 2015 Source: (Funge-Smith, 2018).

Country	inland capture fishery catch (tonnes)(2015)	Percentage of global inland fishery catch
Mozambique	93 020	0.81
Zambia	83 719	0.73
Angola	38 514	0.34
Zimbabwe	10 500	0.09
Namibia	2 800	0.02
South Africa	900	0.01
Botswana	81	0
Eswatini	65	0
Lesotho	52	0

Lake Malawi land about 44 000 tonnes of fish per year, and it is shared between Malawi, Mozambique and Tanzania (Weyl et al., 2010). The Zambezi river system, shared among Zambia, Namibia and Mozambique, is estimated to land about 32 000 tonnes of fish per year in Zambia (Tweddle, 2010). In addition, 2 700 tonnes were the estimated landing in Namibia (Tweddle et al., 2015). Similarly, the Kavango River shared among Angola, Namibia and Botswana has, some years back, been estimated to land between 840 and 3 000 tonnes of fish per year (Sandlund & Tvedten, 1992). Several other inland water bodies in southern Africa contribute significantly to inland fisheries catches, this includes lakes such as Lake Kariba, Lake Cahora Bassa and Lake Tanganyika, and river systems of the Congo River and Limpopo River (AU-IBAR, 2012).

Exploitation of inland fisheries in southern Africa is mainly characterized by multi-species and multi-gear fisheries using a wide range of fishing methods across all trophic levels of fish species (AU-IBAR, 2012; Poilecot, 1996; SADC, 2000). The fisheries are dominated by species of Cichlidae (tilapia), Kapenta (*Limnothrissa miodon*), and Clariidae (catfish). Often fish are exploited by artisanal means, where fishers use traditional fishing gears and crafts, such as fish traps and hook and lines operated from dugout canoes to relatively modern planked boats with or without outboard motors (AU-IBAR, 2012). However, there are few exceptions to semi-industrial fisheries, such as Lake Tanganyika, Lake Malawi, Lake Victoria and the Kariba Dam, where more modern gears and mechanized fishing crafts are used to exploit fish resources (Sandlund & Tvedten, 1992).

Modern gears often include mono-filament gill nets, trawls, Purse seines nets and are closely associated with commercial fisheries. The exploitation of the fisheries using modern gears is often more effective than using traditional gears and often lead to unsustainable fishing practices that threaten the livelihoods of many communities that depend on the fisheries in southern Africa (Abbott et al., 2002). The use of more effective fishing gears for exploiting fish resources are driven by economic and revolutionary shifts in different countries coupled with increasing population within the region (Hay et al., 2020). To reverse the negative development, management interventions are required to mitigate the overexploitation of the fish resources and to ensure that the resource is used sustainably.

1.1.5 Inland fisheries Namibia

Namibia is the driest country in sub-Saharan Africa with surface water in most areas being only available for very limited periods during the year, where most precipitation fall in the northern part of the country (Mupambwa et al., 2019). Approximately 90% of the country's area consists of desert, arid and sub-arid land (MAWRD, 2000). Only about 5% of Namibia's surface area contains freshwater cover, while the majority of the areas are dry most of the time (Bethune et al., 2007).

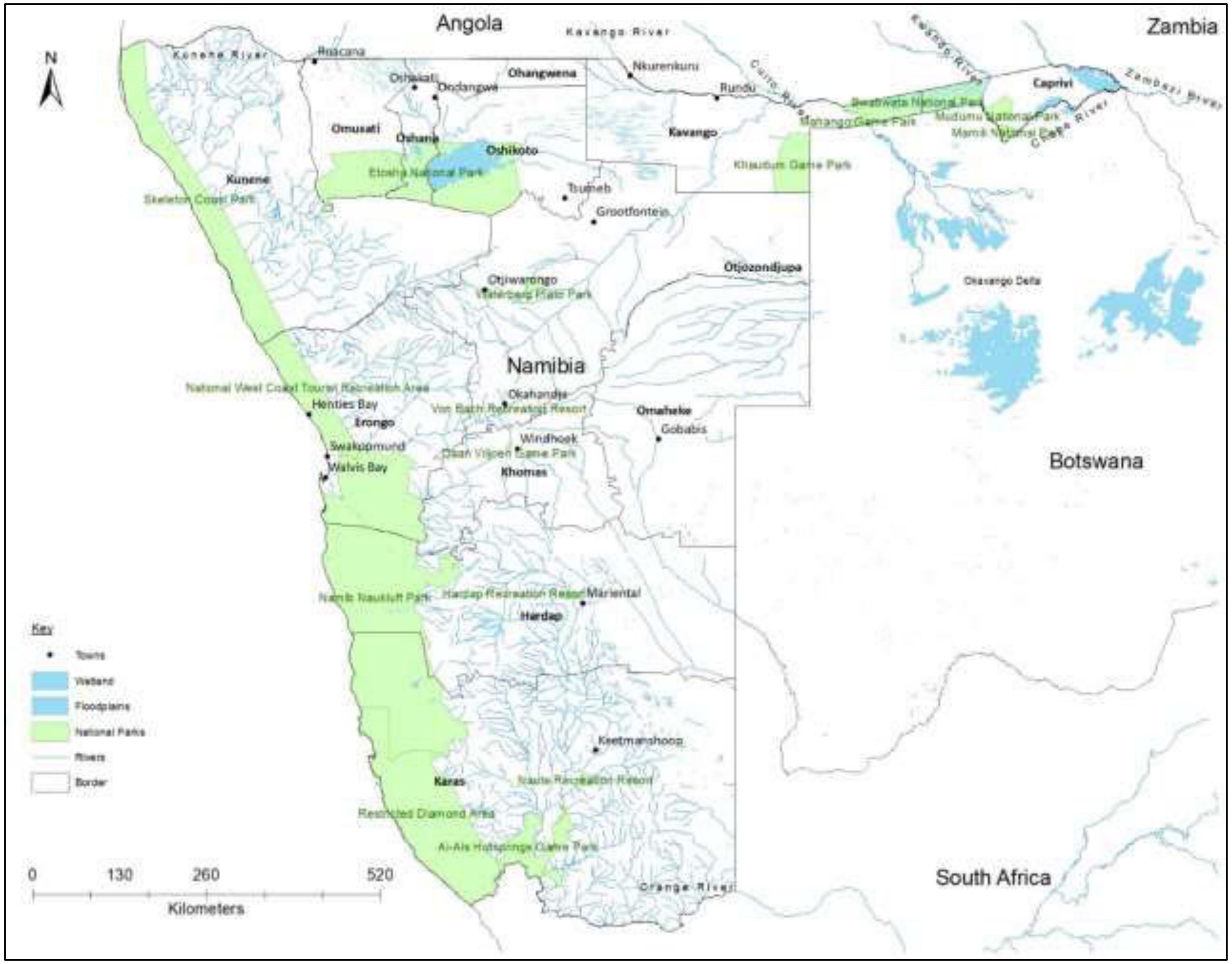

Figure 1: Map of Namibia showing inland water bodies ranging from perennial rivers, ephemeral rivers and a number of reservoirs.

Namibia is characterized by ephemeral rivers, which mostly flow during and after heavy rainfall in their catchment areas (Sandlund & Tvedten, 1992). A number of state dams are built along these ephemeral rivers, for example the Hardap dam and Neckartal dam built on the Fish River (Lillie & Steyn, 2014). Moreover, the dams supply Namibia's mainland with water for human consumption and irrigation for agricultural green schemes (Lillie & Steyn, 2014). In the areas of Grootfontein and Otavi there are remarkable underground lakes with openings (sinkholes) that contain Namibia's blind catfish, *Clarias cavernicola* and *Tilapia guinasana* (Oshikoto tilapia) which are endemic to the country and important for conservation (Jacobs et al., 2021).

Namibia is also home to perennial rivers that are found on the borders of the country, these include the Orange River in the south, Kunene, Kavango, Kwando-Linyanti and Zambezi-Chobe River systems in the north and north-eastern parts of the country (Hay et al., 2000). During and after good rain, perennial rivers in the northern parts of the country receive increasing water cover from their catchment areas resulting in rivers breaking their banks, inundating the large extensive floodplain, swamps and ephemeral lakes (Hay et al., 2000; Peel, 2012).

Floodplains in general, are areas of low lying land that are subject to inundation by lateral overflow water from rivers or lakes with which they are associated (Tockner & Stanford, 2002). Floodplains are considered highly productive more than the parent rivers they are associated with (Tockner & Stanford, 2002). The productivity of floodplains is driven by the flood pulse which is the seasonal fluctuation of water levels (Castello et al., 2015). During the rising of the flood, the water inundates the floodplain where aquatic and terrestrial elements interlink and is called the aquatic/terrestrial transitional zone (ATTZ) (Junk et al., 1989). The ATTZ has a high load of nutrients from terrestrial sources such as vegetation, grazeland and detritus (Junk et al., 1989).

The high nutrient in the ATTZ triggers primary productivity on the floodplain (Roos, 2016). The primary production results in abundant plant-based food resources such as algae, detritus and tree fruits and seeds (Junk et al., 1989). Many fish species time their spawning to coincide with the annual flood, to ensure availability of food for their offspring after spawning (Welcomme, 1985). Floodplains provide fish with habitats for feeding, nursery, a refuge from large fish and spawning grounds for certain species (Welcomme, 1985). Therefore, the occurrence of seasonal floods encompasses the seasonal abundance of fish on the floodplains and subsequently in the main river (Mosepele, 2008).

The Kavango, Kwando-Linyanti, Zambezi-Chobe River systems in the northern parts of the country are subject to such annual floods inundating their adjacent floodplains (Hay et al., 2000). In addition, the seasonal flooding of the Cuvelai River in Angola inundates a series of low-lying land and depressions called iishana in central Namibia (Sandlund & Tvedten, 1992).The iishana fill up with water for about two to four months, during this time they support a short lived fishery exploited by riparian communities (Van Der Waal, 1990). These riparian communities take advantage of the infrequent fish resource as a source of food and nutrition as well as household income (IECN, 2011).

In the Zambezi region, the Zambezi-Chobe floodplain fisheries is crucial in terms of providing food, income and employment for both fishing and non-fishing households (Hay et al., 2020; Purvis, 2002). Similarly to the Zambezi/Chobe floodplain system, the Kwando/Linyanti floodplain system also provides fish as source of food to riparian communities. However, the fishery on the Kwando is not as intense as compared to Zambezi/Chobe fishery. This might be because part of the Kwando river falls under protected area and other part of Linyanti only flows in times of heavy floods (NNF, 2017). Equally important, lake Liambezi situated between Chobe and Linyanti system supports a large fisheries when filled up (Kauluma et al., 2015). The lake can experience a number of dry years followed by intense flooding periods which fill up the lake and the estimated annual yield of lake Liambezi fishery was about 2 700 tonnes for 2011/ 2012 (Peel et al., 2015). During the times the lake fills up, the riparian communities exploit the fish resource as a source of food and income (Revermann et al., 2018). The Zambezi region has a common saying that states, “if you don’t fish then you are not Caprivian” (Tvedten, 2002), this saying is a testimony that stipulates the significance of inland fisheries in the region. Meanwhile, the Kavango river also provides riparian communities with fish as a source of food and income, where the fish resources are exploited mainly for subsistence consumption (Munwela, 2010).

1.1.6 Fisheries in the Kavango region

In the Kavango Regions (East and West), approximately 94% of the 219 090 people live within the 5km of the Kavango river and about 80% of them live in rural areas (Mendelsohn, 2009). The life of the resident communities in the Kavango revolves around farming, mainly crop farming (Haindongo et al., 2019; Munwela, 2010). The Kavango region is classified as the poorest region nationally, with more than half of its population (53.2%) regarded as living in poverty (National Planning Commission, 2015). The high incidence of poverty underlines the importance of riparian communities in harvesting natural resources to cushion their poverty (Barnes et al., 2009). According to Turpie (2008), the fish resource on the Kavango River-floodplain system are mostly open access. Usually, open-access fisheries are accessible easily without restriction resulting in fishers exploiting the resource as to their need; however, this may lead to unsustainable practices and overexploitation of the fish resource (Smith et al., 2005). Open access lead to fishers maximizing their effort often using unsustainable practices in order to maximize their catches, in most cases exceeding the maximum sustainable yield leading overexploitation.

According to Munwela (2010), fishing is mainly subsistence as 61% of fishers in the Kavango keep their fish for own consumption and 37% sell within the village to gain some income. Moreover, fishing is the second most important income in Kavango by 17% after crop production at 25% (Munwela, 2010). Fishing is mainly practiced part-time while engaging in other activities such as crops and livestock farming (Sandlund & Tvedten, 1992). Engaging in other activities minimizes the risk of starvation, and losing income during draught seasons with poor performance of agricultural crops (Turpie, 2008a).

Floodplain-rivers vary within seasons and years, the Kavango River on the Namibian portion is subject to annual flooding of varying intensity, and usually, it starts in December, reaching the peak in March-April and recedes during May (Hay et al., 2000). The flooding intensity and duration of flood depends on the rainfall received from the catchment area in Angola (Hocutt & Johnson, 2001). Similarly to other floodplains, the floodplains on the Kavango River support seasonal abundance of fish species that provide important fisheries to riparian communities (Hocutt & Johnson, 2001; Simasiku & Mafwila, 2017). About 76 fish species have been identified on the Kavango River-floodplain system (Hay et al., 2000). The seasonal abundance of fish on the floodplains is often coupled with increased fishing activities (Abbott et al., 2007). According to Munwela, (2010) females (60%) are more involved in fishing than males (40%) on the Kavango river system. Furthermore, Kangausaru, (2018) indicated that women and children dominate the fishing on the floodplains of the Kavango.

Floodplains are highly dynamic in nature, the fish species and habitat diversity vary with rising, inundated and receding phase of the flood waters (Welcomme & Hagborg, 1977). Fishers often use a succession of different types of fishing gears and methods to adapt to the different periods of flooding intensity and exploit the fish communitites (Mmopelwa et al. 2009). In most cases, different levels of the flooding intensity influence the catchability of gears on different fish species and sizes on floodplains (Welcomme & Hagborg, 1977).

Traditional gears historically recorded in the Kavango River include fish funnels, fish traps, fish fences, scoops baskets, bow and arrow, fish hooks and fish spears, while modern gears include hook and line, gillnets, seine nets and wire mesh fykes (Van Der Waal, 1991). Traditional gears and modern gears have been reported on the Kavango River (Hay et al., 2000; Munwela, 2010; Peel et al., 2015). However, there have been reports of increased use of modern gear. The use of mosquito nets as a modern fishing gear has also been reported in the Kavango River (Hay et al., 2000; Munwela, 2010). Modern fishing gears are effective and efficient to use than traditional gears and they have been introduced mostly to cope with the demand in fish and fish products from the increasing human population (Hay et al., 2000; Tweddle et al., 2010).

1.1.7 Fisheries management

In Namibia, floodplain fisheries are characterized by multiple-species and multiple-gear coupled with diverse fishing methods which is compelled by varying floodplain habitats (Hay et al., 2000; Peel, 2012). Most floodplain fisheries in Namibia are open access meaning participation and harvesting of fish remains unrestricted, individuals can access the resource without seeking permission from anyone (Allcorn, 1999). “The fisheries are, however, threatened by increasing fishing effort and require proper management to prevent overfishing which poses serious threats to biodiversity and to the sustainability of fisheries and the livelihoods of those who depend on them" (Peel, 2012). The Ministry of Fisheries and Marine Resources (MFMR) have technical measures in place to prevent the unsustainable practices of exploitation involving effort regulation through fishing licenses, gear restriction, prohibition of destructive fishing methods and closed fishing season.

The MFMR through its mandate manages all living aquatic resources and continuously ensure conducive environment for fishing and aquaculture sector prosperity for today and the future generations to come (MFMR, 2017). The Inland Fisheries Policy of Namibia (White Paper on the Responsible Management of the Inland Fisheries of Namibia, 1995) states that "Resources will be managed to ensure long term food security to the riparian populations who will be involved in the management and control of the resources".

1.2 Problem statement

Floodplain fisheries are important to communities along the Kavango River as 50% of the population depend on the fish resource to sustain their livelihoods (Hay et al., 2000; Munwela, 2010). However, recent studies have shown that there has been a decline in fish species in the Kavango River and it is attributed to an increase in fishing effort (Hay & van der Waal, 2009, Peel 2012). Most of these studies have been focusing more on open-water (main river) fisheries and few exception on the floodplain fisheries. Hence, this study aims to assess the assess fishers' catches, effort and fishing gear on the Kamutjonga floodplain to better understand the fisheries dynamics of the floodplain and used to inform decision-makers towards better management of the fish resource on floodplains.

1.3 Objectives of the study

a) Determine the flood cycle partten of the Kamutjonga floodplain

b) Determine the type of fishing gears, method and fishing patterns on the Kamutjonga floodplain

c) Determine the frequency of fishers, number of fisher days, gear utilization and fishing duration of fishing on the Kamutjonga floodplain

d) Determine the catch composition on the Kamutjonga floodplain in two flood cycles, fishing gears and in the different phases of the flood cycle

e) Determine and compare the body length distribution of fish on the Kamutjonga floodplain in two flood cycles, fishing gears and the different phases of the flood cycle.

f) Determine and compare the catch per unit effort (Number per unit effort/Weight per unit effort) between the fishing gears and the two flood cycles on the Kamutjonga floodplain

g) Determine the total catch estimate of the Kamutjonga floodplain in two flood cycles, fishing gears and in the different phases of the flood cycle

1.4 Hypothesis

a) There is no significant difference between the body length distribution of fish caught in various fishing gears on the Kamutjonga floodplain

b) There is no significant difference between the body length distribution of fish caught in the different phases of the floodcycle on the Kamutjonga floodplain

c) There is no significant difference in CPUE between various fishing gears used by fishers along the Kamutjonga floodplain

d) There is no significant difference in CPUE of the same gear used by fishers btween 2018 and 2020 flood cycle along the Kamutjonga floodplain

1.5 Significance of the study

The study will provide information that will help researchers and managers to better understand the type of gear utilized of the floodplains, catch composition and fish size of different gears, catch per unit effort of gears utilized in relation to the dynamics of the flood cycle. In addition, the fish yield of the study area shall be estimated.The information obtained from the study will enable them to recommend and advice management measures to ensure sustainable utilization of the fish resource both on the floodplain and, subsequently the main river. Sustainable utilization of the fish resource on the Kavango River-floodplain system will ensure the availability of fish as a source of food, income and employment to many riparian communities in Kavango Region.

2 RESEARCH METHODS

2.1 Description of the study area

The Kavango River, originates from central Angola and flows southward towards Namibia before turning east to form the 415 km Namibia/Angola border, ending in the 15 000 km^2 Okavango Delta in Botswana (Hocutt & Johnson, 2001). During the flood pulse water from the mainstream spill over into the adjacent floodplains which provide livelihoods to the Kavango Region inhabitants who reside within 5 km of the river (Hay et al., 2000). The floodplain serves multiple purposes to the local communities, during the flooding season it becomes a fishing hot-spot mainly for women and children, whilst during the dry season it is mostly utilized for small scale pastoralism.

The study focused on the Kamutjonga floodplain situated approximately 20 km south-east of Divundu in the Mukwe constituency (Figure 2*:*). The Kamutjonga floodplain extends approximately 17 km in length, 2 km at its widest point and nearly 2 m in depth when inundated by the annual flood. The Kamutjonga floodplain is in close proximity with the Ministry of Fisheries and Marine Resources' Kamutjonga Inland Fisheries Institute (KIFI).

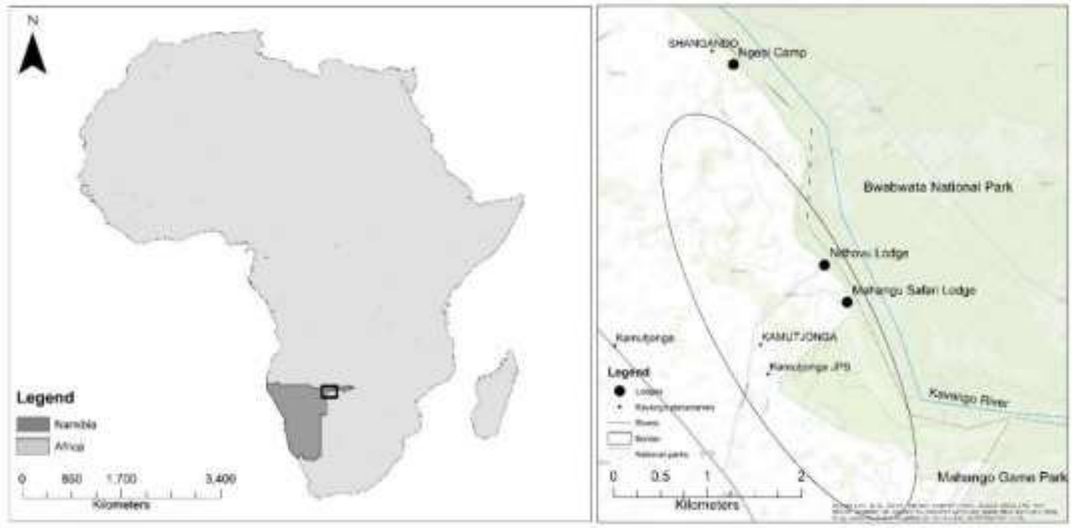

Figure 2: Map of Africa showing the location of Namibia and the location of the study site.

The area has a semi-arid climate, which receives an average rainfall of 500-600 mm/year, occurring mostly from October to April (Mendelsohn, 2009). The floodplain is surrounded by large well-developed tree species such as blackthorn (*Senegalia mellifera*); *Combretum imperde; Senegalia nigrescens* as well as the camel thorn tree (*Vechelia erioloba)*. The floodplain is comprised of a mixture of terrestrial and aquatic grasses, such as the pearly love grass (*Eragrostis rotifer*) and sedges (Cyperaceae) (Hines, 1998).

During the rising of the flood, the newly inundated floodplain is rich in nutrients and triggers aquatic primary production (Siziba et al., 2011). The rich nutrient initiates phytoplankton production, growth of submerged and floating macrophytes and other various aquatic plants (Bethune, 1991). Fish find in the inundated floodplain suitable habitats for feeding and nursery, refuge from predation and spawning grounds (Mosepele, 2019). The fish that migrate into the floodplain, eventually turns into provides food for riparian communities.

2.2 DATA COLLECTION

The study was carried out on the Kamutjonga floodplain along the Kavango River during the 2018 and 2020 flood cycles. It is important to note that no flooding occurred in 2019 due to low rainfall in the catchment areas of the Kavango River. The study collected data on type of fishing gears, method, fishing patterns, fishing effort (number of fishers per gear, number of fishing gears and time spent fishing) and fishery catches during the two flood seasons. Data sampling was done daily at 08:00, 11:00, 15:00 and 18:00 from 18 february – 11 june in 2018 and from 06 february -21 June in 2020. During sampling, the fishing effort of fishers were obtained by observation and actual counting of individual fishers and those that were sharing fishing gear classified as fisherday(s). A fisherday was defined as an individual fisher or a group of fishers using a particular gear(s) to obtain the catch with the duration of fishing taken into consideration. Types of fishing gears utilized by fishers were identified and counted and recorded accordingly. Individual fisher or a group of fishers were selected from the rest of the fishers daily based on the willngess for their fish to be sampled and each day the enumerators made sure to sample different fishers from the previous fishers whose fish have been sampled already. From the selected fishers, their fish catches were identified to species level, counted, total or fork length (depending on species) measured (mm) and the whole fish weighed (g) and for the rest of the fishers whose fish were not sampled, only their effort were recorded (type of gear used, number of fishing gears, time spent fishing) (Figure 3). The time spent fishing by fishers on the floodplain was also recorded and this was inclusive of fisherdays whose fish were sampled and those whose fish were not sampled (non-sampled fisherdays) but their fishing effort (fishing gear and time spent fishing) were recorded. Therefore, the fishing duration given in this study is inclusive of sampled fisherdays and non-sampled fisherdays. Data were entered into Microsoft Excel and Pasgear 2 for basic analysis (Kolding & Skaalevik 2018) a database designed for experimental or artisanal fishery data. Statistical analyses were performed using IBM SPSS Statistics ver. 25 and Microsoft Excel, 2016.

Figure 3: Sampling of fishers on the Kamutjonga floodplain, inundated floodplain (A), fishers fishing with a mosquito net (B), traditional trap (C), fisher using a hook and line and his catch (D), a fisher with his catch (E), identifying, weighing, measuring and recording of fish (F).

2.3 Data analysis

Catch composition

In catch composition Index of relative importance was applied as a measure of relative abundance or commonness of different species in the catch and (%IRI, Kolding 1989) is used

$$\% \, IRI_i = \frac{(\%W_i + \%N_i) \times \%f_i}{\sum_{j=1}^{s}(\%W_j + \%N_j) \times \%f_j} \times 100$$

where %Wi and %Ni is percentage weight and number of each species of total catch, %Fi is percentage frequency of occurrence of each species in total number of settings, and S is total number of species. (PASGEAR version 2.3).

Catch per unit effort

Fisher's CPUE is defined as the number or weight of fish caught per gear per hour. CPUE was calculated as:

CPUE = C*i*/E*i*,

Where C*i* is the catch of species *i* (in numbers or weight) and E*i* is the effort expended to obtain the catch. The CPUE was standardized as number or weight per gear per hour (*n* or *kg*/gear/hr).

Estimated catch

The estimated total catch on the Kamutjonga floodplain was calculated as the average catch per unit effort in kilograms or numbers (C*i*/E*i*) times the hours fished each day H*i* and the number of gears G*i*. Where C*i* is the catch of species *i* (in numbers or weight), Ei is the effort expended to obtain the catch, Hi ishours fished each day and Gi the number of gears.

$$\text{Total estimated catch for fisher day} = \Sigma\,(Ci/Ei) \times (Hi \times Gi)$$

Statistical analysis

An assessment of the normality of fishers catches data was carried out using a Kolmogorov-Smirnov test (SPSS version 24). A Kruskal-Wallis *h* test was used to examine the variations in relative abundance (CPUE) of fish species between gears for each year. A pairwise comparison was used to determine which gear brought about the variation. Mann-Whitney U test was applied to determine the differences in the CPUE of each gears between the two flooding seasons. Variations in total body length distribution between fishing gears were compared using the non-parametric Kruskal-Wallis one-way analysis of variance (ANOVA), and a Mann-Whitney U-test was used for pair-wise comparison. The Variations in total body length distribution between flooding phases were compared using the non-parametric Kruskal-Wallis one-way analysis of variance (ANOVA). A 95% confidence level was used in all tests.

3 RESULTS

3.1 Flood cycle pattern of the Kamutjonga floodplain during 2018 and 2020

In this study, the flooding patterns were categorized into three flooding phases namely the rising, high/inundated and receding phase, which were classified according to the depth measured daily at a specific point (Table 2).The rising phase was classified as the initial inflow of floodwaters into the floodplain and classified between 0.1 m - 0.99 m. The high or inundated phase was classified as the maximum inundated water level > 1 m, and the receding phase was classified when the water level receded and the depth measured was < 1 m. During the study period, the flooding intensity differed between 2018 and 2020 flood cycle. The 2020 flood cycle was much higher than the 2018 flood cycle. However, the three different phases were classified at fixed and constant depth levels, despite the dynamics of the flood during two flood cycle.

In 2018, the rising phase comprised of the most days (66 days) while the high phase and receding phase were 23 and 24 days, respectively. In 2020 the high phase comprised of the most days (81 days) and the rising and receding phase were 21 and 34 days, respectively. During 2018 and 2020, the Kamutjonga floodplain experienced flooding of varying intensities. In both years, the seasonal flooding occurred from February to June, whereas in 2018, the flood lasted for 16 weeks (113 days) and 20 weeks (136 days) in 2020 (Figure 4). The flood experienced on the Kamutjonga floodplain reached the peak at 1.35 m during 2018 and 2.15 m in 2020.

Table 2: Different phases of flood cycle on the Kamutjonga floodplain in 2018 and 2020.

		Seasonal Floodcycle phases		
		Rising phase	**High phase**	**Receding phase**
Depth (m)		< 1	1 ≥	< 1
2018	Date	18 February- 25 April	26 April – 18 May	19 May – 11 June
	Days	66	23	24
2020	Date	06 February - 26 February	27 February – 16 May	17 May – 21 June
	Days	21	81	34

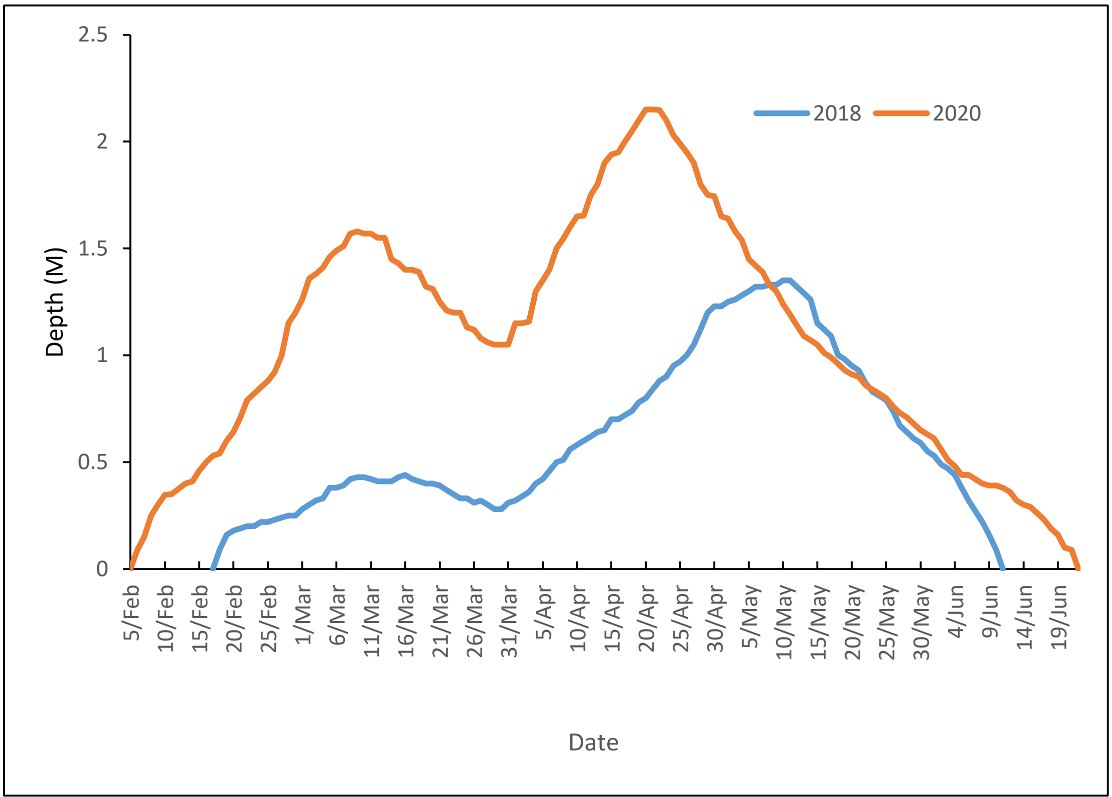

Figure 4: Seasonal flood cycle pattern of the Kamutjonga floodplain (2018 and 2020).

3.2 Fishing gears and gear utilization on the Kamutjonga floodplain

3.2.1 Plastic containers

Plastic containers were utilized as fishing gears on the floodplain. The plastic containers were cut out of 2 litre and 5 litre plastic bottles and were perforated to easy the pressure from the current. The plastic containers were baited with porridge and placed in shallow water of the floodplain. A fisher could have 2 or more plastic containers utilized on a particular day. The plastic containers were usually set up in the preferred area of the fishers' preference. Once set up, the plasctic containers were usually left for about 20-30 minutes before retrieving the fish that were traped in the gear and this was done repeatedly until the fishing ends on that particular day

Figure: 5 Plastic container fishing gear set in shallow vegetion on the floodplain

3.2.2 Mosquito nets

Mosquito nets were utilized as fishing gears on the Kamutjonga floodplain. Mosquito net have small mesh-size of ≤ 3 mm and are used as small light-weight seine net. The mosquito nets were dragged as a seine in shallow water of floodplain for about 2 – 10 m distance to catch the fish. Mosquito nets were operated by 2 or more fishers per gear and some of them assited in chasing the school of fish towards the gear. Reapeted drags were done until the fishers were satisfied with their catch.

Figure: 6 Mosquito nets being utilized by fishers on the Kamutjonga floodplain

3.2.3 Hook and line

Hook and line fishing gear utilized on the Kamujonga floodplain were constructed using a single hook (various sizes and shapes). This hook was tied to a twine of either a nylon or monofilament twine. The twine was 2 – 10m long and was affixed to a straight thin rod made from local reeds or shrubs. Hooks on the complete fishing gear were baited with earthworms to lure the fish. The hook was casted several times in the water secured by the twine to catch the fish, while the fisher stands on the shoreline or a dugout canoe holding on to the rod. In the local language, hook and line is called Dirovo. Van Der Waal (1991) similarly described the same fishing gear being utilized on the Kavango river system .

Figure: 7 Hook and line fishers engaging in fishing on the Kamutjonga floodplain

3.2.4 Traditional trap

Traditional traps fishing gear utilized on the Kamutjonga floodplain were constructed in a rectangular mat-like structure made out of thin wooden sterms of local shrubs. The mat was usually 50-80 cm in height and 50 – 120 cm in length. The sterms were secured using petiole sedges leaving gaps in between the sterms. The sterms were sharpened at one-end to sucure the mat in the soil once set up. The traditional trap mat was usually set up in shallow water in a concave shape leaving a small opening for fish to enter. The mat was secured in the soil under water using the sharpened end, while the other end was out of the water. The traps were usually set up in the preferred area of the fishers' preference. Once set up, the traps were usually left for about 20-30 minutes before retrieving the fish that were traped in the gear and this was done repeatedly until the fishing ends on that particular day. (Van Der Waal, 1991) similarly described the same fishing gear being utilized on the Kavango river system .

Figure: 8 Traditional traps fishing gear used on the Kamutjonga floodplain

3.3 Fishing gear, frequency of fishers and gear utilization

3.3.1 Fishing gear

Four different fishing gears were recorded on the Kamutjonga floodplain during the study period. This include plastic containers, mosquito nets, hook and line and traditional traps. In 2018, a total of 72 plastic containers, 53 mosquito nets, 109 hook and line and 24 traditional traps were recorded on the Kamutjonga floodplain. In 2020, a total of 13 plastic containers were recorded, 59 mosquito nets, 327 hook and line and 63 traditional trap.

Table: 3 Number of fishing gears utilised on the Kamutjonga floodplain during the different phases of the flood cycle in the 2018 and 2020 study period

	Seasonal flood cycle phases							
	Rising		High		Receding		Total	
Gear	2018	2020	2018	2020	2018	2020	2018	2020
Plastic containers	71	9	1	4	0	0	72	13
Mosquito nets	41	31	2	28	10	0	53	59
Hook and line	29	0	0	251	80	76	109	327
Traditional traps	8	0	14	63	2	0	24	63

3.3.2 Frequecy of fishers and gear utilization during the 2018 flood cycle

In 2018 (Figure 9), a frequency of 398 fishers were recorded to be fishing on the Kamutjonga floodplain consisting of 287 (72 %) females and 111 (28 %) males. Plastic containers, mosquito nets, hook and line and traditional traps were recorded as fishing gears utilized. A frequency of females dominated the use of all fishing gears except for hook and line. Plastic containers were utilized by 104 females and 2 males, mosquito nets were utilized by 144 females and 14 males, traditional traps were utilized by 24 females. While hook and line were utilized by 15 females and 95 males.

During the rising phase of flood, a frequency of 279 fishers were recorded consisting of 239 females and 40 males. Plastic containers were utilized by 102 females and 2 males, mosquito nets were utilized by 129 females and 8 males, while hook and line were utilized by 30 males, and traditional traps were utilized by 8 females. During the high phase of the flood, a frequency of 23 fishers were recorded consisting of only female fishers. Plastic containers were utilized by two females, mosquito nets were utilized by seven females, traditional traps was utilized by 14 females, while hook and line was not utilized at all during the high phase. During the receding phase of the flood, a frequency of 71 fishers were recorded, consisting of 25 females and 71 males.

Plastic containers were not utilized during the receding phase of the flood, while mosquito nets were utilized by 8 females and 6 males, hooks and line were utilized by 15 females and 65 males, traditional traps were utilized by 2 females.

3.3.3 Frequecy of fishers and gear utilization during the 2020 flood cycle

In 2020 (Figure 9), a frequency of 569 individuals were recorded fishing on the Kamutjonga floodplain consisting of 325 (57 %) female and 244 (43 %) male. Plastic containers, mosquito nets, hook and line and traditional traps were recorded as fishing gears utilized on the Kamutjonga floodplain during the 2020 flood cycle. A frequency of females dominated the use of all fishing gears except for hook and line. Plastic containers were utilized by 11 females, mosquito nets were utilized by 175 females and one male, traditional traps were utilized by 69 females. In contrast, hook and line were utilized by 70 females and 243 males.

During the rising phase flood, a frequency of 101 fishers were recorded consisting of 100 females and 1 male. Plastic containers were utilized by 10 females, mosquito nets 90 females and 1 male, hook and line and traditional traps were not utilized during the rising phase of flood. During the high phase of the flood, a frequency of 388 fishers were recorded consisting of 195 females and 193 males. Plastic containers were utilized by 1 female, mosquito nets were utilized by 85 females, hook and line were utilized by 44 females and 193 males, traditional traps were utilized by 65 females. During the receding phase of the flood, a frequency of 80 fishers were recorded consisting of 50 males and 30 females. Plastic containers and mosquito nets were not utilized, while hook and line were utilized by 26 females and 50 males, traditional traps were utilized by 4 females.

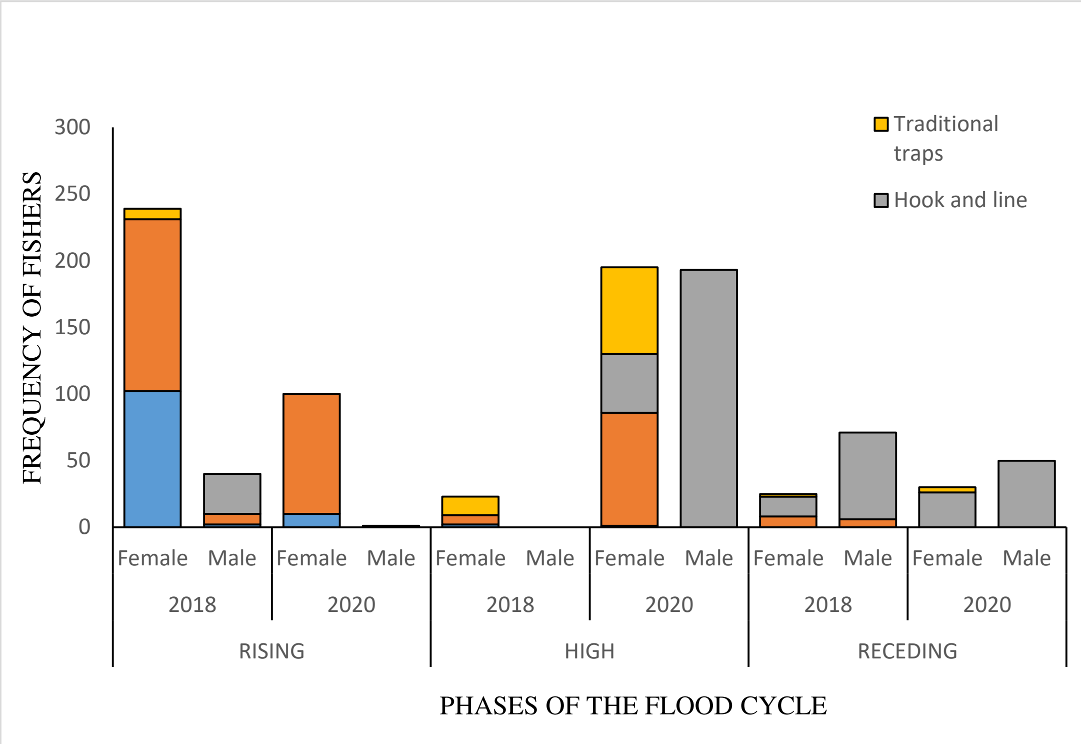

Figure 9: Frequency of gear used in different phases of the flood cycle by gender.

3.4 Gear utilization based on fisher days

3.4.1 Fisherdays over the phases of the flood cycle

In 2018 (Table 4), a total of 254 fisherdays were recorded of the Kamutjonga floodplain. 146 fisherdays were recorded during the rising phase of the flood, 16 fisher days were recorded during the high phase of the flood and 92 fisherdays were recorded during the receding phase of the flood. In 2020 (Table 4), a total of 462 fisherdays were recorded on the Kamutjonga floodplain. 38 fisherdays were recorded during the rising phase of the flood, 376 fisher days were recorded during the high phase of the flood and 48 fisher days were recorded during the receding phase of the flood.

Table 4: Fisher days and the average fisher days on the Kamutjonga floodplain during the different phases of the flood cycle in the 2018 and 2020 study period.

		Seasonal Floodcycle phases			
Year		Rising phase	High phase	Receding phase	Total
2018	Fisher days	146	16	92	254
	Average fisher days	4 (± SE 0.30)	2 (± SE 0.22)	8 (± SE 1.83)	
2020	Fisher days	38	376	48	462
	Average fisher days	9 (± SE 0.96)	17 (± SE 2.65)	8 (± SE 1.51)	

3.4.2 Fisher days and gear utilization over the phases of flood cycle

Fishers on the Kamutjonga floodplain utilized different fishing gears to adapt to changes in depth over the flood cycle.

In 2018 (Figure 10), fishing during the rising phase of the flood was predominantly carried out using plastic containers (70 fisherdays), followed by mosquito nets (41 fisher days), hook and line (28 fisher days) and traditional traps (8 fisher days). Fishing during the high phase was predominantly carried out using traditional traps (14 fisher days), followed by mosquito nets (two fisher days) and no hook and line utilized. While, fishing during the receding phase was predominantly carried out using hook and line (80 fisher days), followed by mosquito nets (10 fisher days), traditional traps (two fisher days) and no plastic containers utilized. Overall, the dominantly utilized fishing gear in 2018 was hook and line (104 fisher days), followed by plastic containers (74 fisher days), mosquito nets (54 fisher days) and traditional traps (24 fisher days) (Figure 11).

In 2020 (Figure 10), fishing during the rising phase of the flood was predominantly carried out using mosquito nets (31 fisher days), followed by plastic containers (9 fisher days) and no traditional traps and hook and line utilized. Fishing during the high phase was predominantly carried out using hook and line (251 fisher days), followed by traditional traps (63 fisher days), mosquito nets (28 fisher days) and plastic containers (4 fisher days). While, fishing during the receding phase was dominantly carried out using hook and line (76 fisher days) and no plastic containers, mosquito nets and traditional traps utilized. Overall, the dominantly utilized fishing gear in 2020 was hook and line (327 fisher days), followed by traditional traps (63 fisher days), Mosquito nets (59 fisher days) and plastic containers (13 fisher days) (Figure 11).

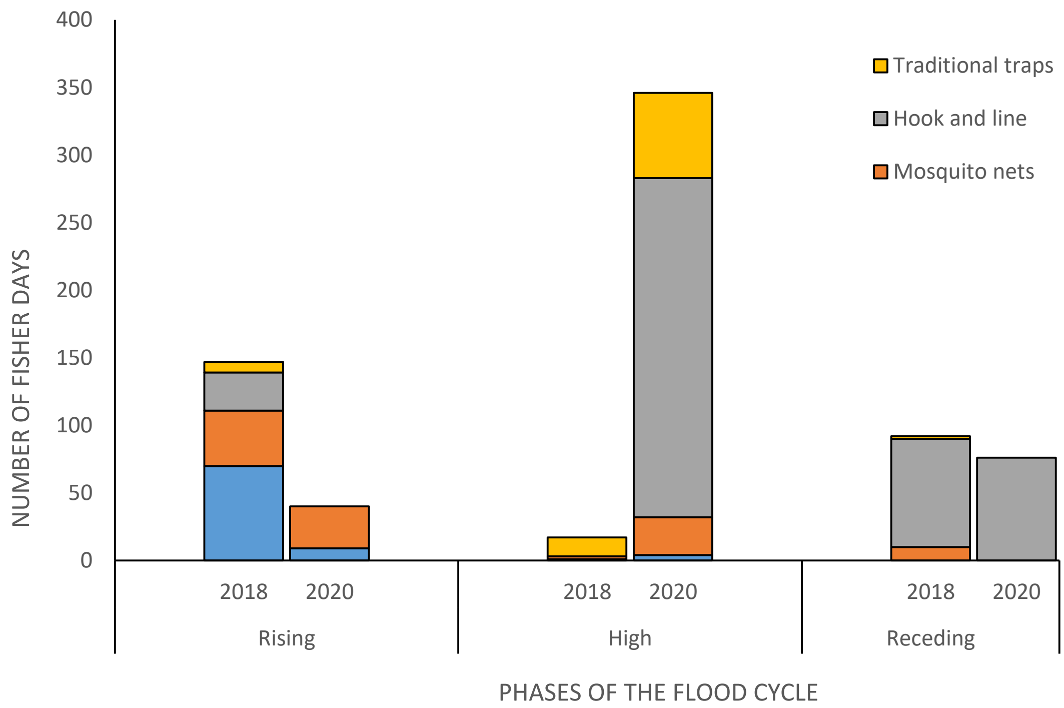

Figure 10: Frequency of gear utilization by fishers during the different phases of the flood cycle in the 2018 and 2020 study period.

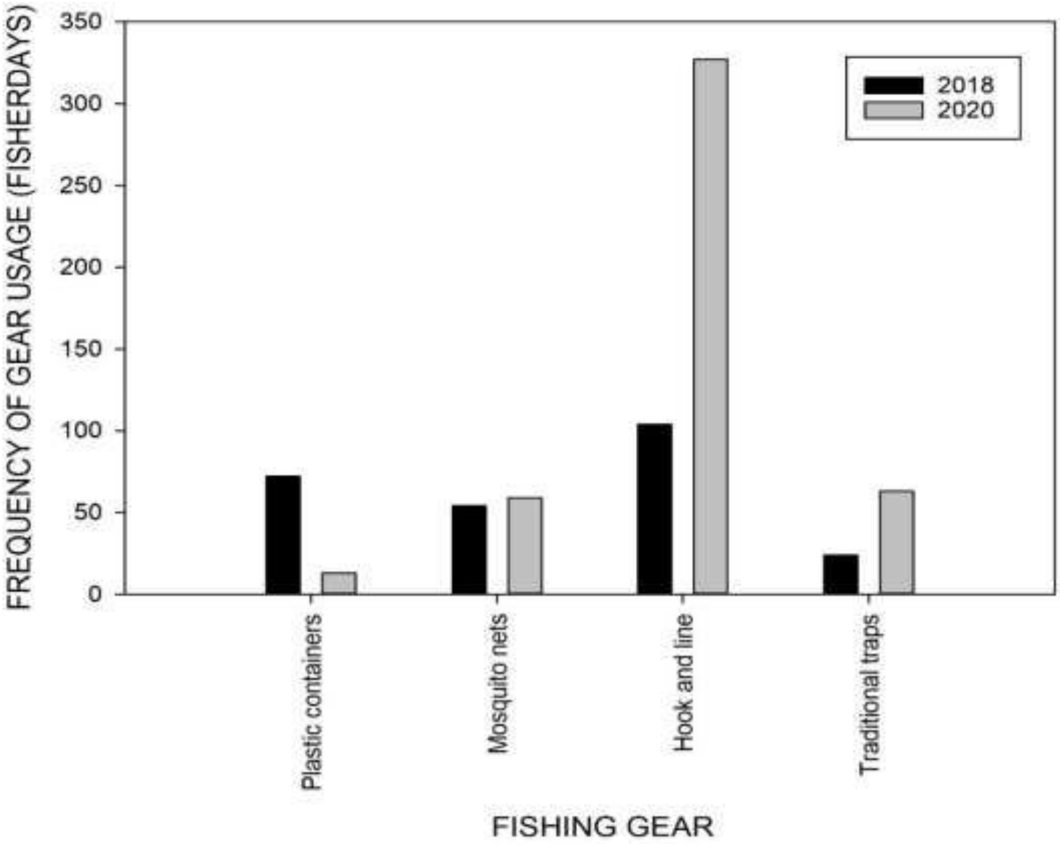

Figure 11: Frequency of gear utilization by fisher during the entire flood cycle of 2018 and 2020 study period.

3.5 Fishing duration on the Kamutjonga floodplain

In 2018 (Table 5), the highest fishing time by gear was recorded for hook and line (465 hrs), followed by plastic containers (347 hrs), mosquito nets (232 hrs) and traditional traps (82 hrs). The highest number of fishing time by phase was recorded during the rising phase (670 hrs), followed by the receding phase (426 hrs) and the high phase being the least (30 hrs). During the rising phase of 2018, the highest time spent fishing was with plastic containers (343 hrs), while hook and line was the highest in the high (19 hrs) and receding phase (348 hrs).

In 2020 (Table 5), the highest fishing time by gear was recorded for hook and line (634 hrs), followed by traditional traps (384 hrs), mosquito nets (304 hrs) and plastic containers (65 hrs). The time spent fishing in different phases of the flood cycle was the highest during the high phase (722 hrs), followed by the receding phase (488 hrs) and the rising phase (176 hrs). During the rising phase, the highest time spent fishing was with mosquito nets (131 hrs), while traditional traps (384 hrs) and hook and line (488 hrs) were the highest during the high and receding phase respectively.

Table 5: Fishing duration in total hours/phase and average hours/day for the different gears utilized during the different phases of the flood cycle on the Kamutjonga floodplain during the 2018 and 2020 study period.

		Seasonal Flood cycle phases					
		Rising		High		Receding	
Gear		2018	2020	2018	2020	2018	2020
Plastic containers	Total hours	343	45	5	20	-	-
	Average hour/day	5.72	0.75	0.08	0.33	-	-
Mosquito nets	Total hours	183	131	7	173	42	-
	Average hour/day	3.05	2.18	0.12	2.88	0.70	-
Hook and line	Total hours	99	-	19	145	348	488
	Average hour/day	1.65	-	0.32	2.42	5.80	8.13
Traditional traps	Total hours	46	-	-	384	36	-
	Average hour/day	0.77	-	-	6.40	0.60	-

3.6 Catch composition of the fishers during 2018 and 2020

3.6.1 Catch composition by family

Nine fish families were caught on the Kamutjonga floodplain during both in the 2018 and 2020 flooding season (Figure 12). Cichlidae was the most dominant family in both years and were represented by 11 species. Cyprinidae was the second most dominant family representing eight and nine species in 2020 and 2018, respectively. Alestidae was represented by 3 species and Clariidae by 2 species in 2018 and 2020 respectively. Poelicidae, Hepsetidae, Anabatidae, Schilbeidae, and Mochokidae were represented by one species for each year.

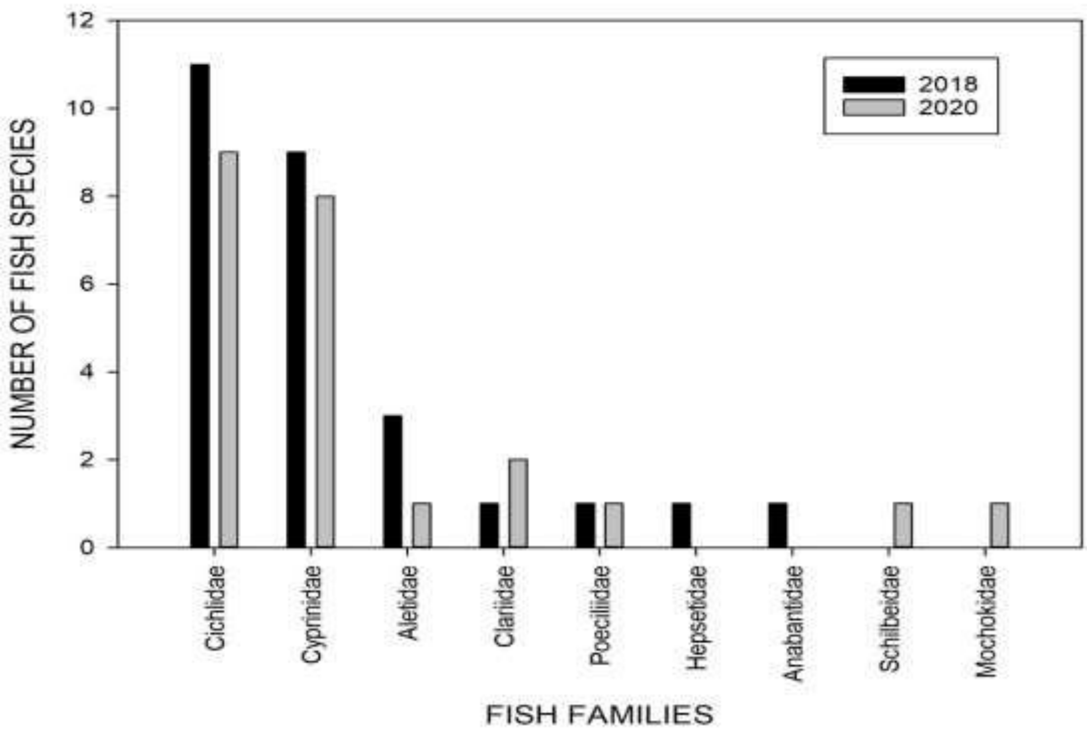

Figure 12 Catch composition (N) by families in 2018 and 2020.

3.6.2 Catch composition by species

In 2018, a total of 27 fish species consisting of 17 386 individual fish weighing 49.75 kg were recorded from the fisher catches on the Kamutjonga floodplain. According to the index of relative importance (%IRI), the five most important fish species in 2018 were *Oreochromis andersonii* (79.6%), *Coptodon rendalli* (9.9%), *Pseudocrenilabrus philander* (3.8%), *Hydrocynus vittatus* (2.3%) and *Serranochromis angusticeps* (1.4%) (

Table 6).

In 2020, a total of 23 fish species consisting of 28 743 individual fish weighing 183.12 kg were recorded on the Kamutjonga floodplain. According to the index of relative importance (%IRI), the five most important fish species in 2020 were *Oreochromis andersonii* (65.5%), *Coptodon rendalli* (29.8%), *Hydrocynus vittatus* (1.8%), *Serranochromis macrocephalus* (0.9%) and *Pharyngochromis acuticeps* (0.7%) (

Table 7).

Table 6: Species composition in number (No), weight (kg), frequency of occurrence (FRQ) and index of relative importance (IRI) recorded from all fishing gears utilized on the Kamutjonga floodplain during the 2018 study period. All measures are given in absolute values and in percentage.

Species	No	%	W (kg)	%	FRQ	%	IRI	%
Oreochromis andersonii	12199	70.2	32.03	64.9	76	94.0	12673	77.3
Coptodon rendalli	883	5.1	10.43	21.1	62	77.0	2007	12.2
Pseudocrenilabrus philander	1343	7.7	1.03	2.1	47	58.0	569	3.5
Hydrocynus vittatus	1384	8.0	2.16	4.4	34	42.0	518	3.2

Serranochromis angusticeps	659	3.8	1.64	3.3	48	59.0	422	2.6
Enteromius bifrenatus	239	1.4	0.15	0.3	28	35.0	58	0.4
Enteromius radiatus	185	1.1	0.36	0.7	20	25.0	44	0.3
Tilapia sparrmanii	73	0.4	0.43	0.9	24	30.0	38	0.2
Tilapia ruweti	102	0.6	0.38	0.8	13	16.0	22	0.1
Enteromius poechii	43	0.2	0.07	0.1	21	26.0	10	0.1
Enteromius barnardi	76	0.4	0.04	0.1	13	16.0	8	0.1
Enteromius fasciolatus	74	0.4	0.06	0.1	7	9.0	5	0.0
Micropanchax johnstoni	60	0.3	0.02	0.0	8	10.0	4	0.0
Serranochromis macrocephalus	7	0.0	0.14	0.3	5	6.0	2	0.0
Sargochromis greenwoodi	8	0.0	0.09	0.2	5	6.0	1	0.0
Pharyngochromis acuticeps	6	0.0	0.08	0.2	4	5.0	1	0.0
Clarias gariepinus	6	0.0	0.09	0.2	3	4.0	1	0.0
Enteromius paludinosus	9	0.1	0.03	0.1	3	4.0	0	0.0
Enteromius unitaeniatus	6	0.0	0.01	0.0	5	6.0	0	0.0
Enteromius eutaenia	7	0.0	0.00	0.0	3	4.0	0	0.0
Micralestes acutidens	7	0.0	0.01	0.0	2	3.0	0	0.0
Oreochromis macrochir	1	0.0	0.05	0.1	1	1.0	0	0.0

Serranochromis altus	3	0.0	0.01	0.0	2	3.0	0	0.0
Hepsetus cuvieri	1	0.0	0.01	0.0	1	1.0	0	0.0
Brycinus lateralis	2	0.0	0.00	0.0	1	1.0	0	0.0
Ctenopoma multispine	1	0.0	0.01	0.0	1	1.0	0	0.0
Labeo lunatus	1	0.0	0.00	0.0	1	1.0	0	0.0
Total	17385	100	49.35	100	-	-	16385	100

Table 7**:** Species composition in number (No), weight (kg), frequency of occurrence (FRQ) and index of relative importance (IRI) recorded from all fishing gears utilized on the Kamutjonga floodplain during the 2020 study period. All measures are given in absolute values and in percentage.

Species	No	%	W(kg)	%	FRQ	%	IRI	%
Oreochromis andersonii	21242	73.9	87.42	47.7	44	95.7	11635	65.5
Coptodon rendalli	4435	15.4	70.91	38.7	45	97.8	5297	29.8
Hydrocynus vittatus	1075	3.7	3.23	1.8	27	58.7	323	1.8
Serranochromis macrocephalus	174	0.6	7.66	4.2	15	32.6	156	0.9
Pharyngochromis acuticeps	228	0.8	2.69	1.5	25	54.3	123	0.7
Serranochromis altus	203	0.7	1.51	0.8	21	45.7	70	0.4
Enteromius paludinosus	382	1.3	2.63	1.4	9	19.6	54	0.3
Tilapia sparrmanii	89	0.3	1.32	0.7	15	32.6	34	0.2
Clarias gariepinus	9	0.0	2.95	1.6	5	10.9	18	0.1
Enteromius unitaeniatus	140	0.5	0.30	0.2	8	17.4	11	0.1
Enteromius barnardi	131	0.5	0.44	0.2	6	13	9	0.1

Enteromius fasciolatus	133	0.5	0.16	0.1	7	15.2	8	0.0
Pseudocrenilabrus philander	70	0.2	0.17	0.1	11	23.9	8	0.0
Tilapia ruweti	68	0.2	0.20	0.1	7	15.2	5	0.0
Enteromius poechii	70	0.2	0.24	0.1	6	13	5	0.0
Labeo cylindricus	167	0.6	0.25	0.1	3	6.5	5	0.0
Enteromius radiatus	44	0.2	0.12	0.1	6	13	3	0.0
Micropanchax johnstoni	48	0.2	0.03	0	7	15.2	3	0.0
Clarias ngamensis	8	0.0	0.38	0.2	3	6.5	2	0.0
Enteromius bifrenatus	18	0.1	0.01	0	4	8.7	1	0.0
Synodontis nigromaculatus	4	0.0	0.47	0.3	1	2.2	1	0.0
Schilbe intermedius	5	0.0	0.02	0	4	8.7	0	0.0
Oreochromis macrochir	1	0.0	0.01	0	1	2.2	0	0.0
Total	28744	100	183.12	100	-	-	17771	100

3.6.3 Catch composition by species in different phases of the flood cycles

In 2018, most of the fish in numbers were caught during the rising of the flood, where a total 15 664 individual fish were recorded, while 741 were caught during high phase and 980 during the receding phase(see Appendix *3Appendix 2*). During the rising phase 25 fish species were recorded and the five most numerous species by percentage number were *Oreochromis andersonii* (72.9%), *Hydrocynus vittatus* (8.8%), *Pseudocrenilabrus philander* (7.8%), *Coptodon rendalli* (2.4%) and *Serranochromis* *angusticeps* (3.7%). In the high phase 13 fish species were recorded and the five most numerous species were *Oreochromis andersonii* (47.8 %), *Pseudocrenilabrus philander* (13.9%), *Coptodon rendalli* (13.4%), *Enteromius bifrenatus* (11.3%), and *Serranochromis angusticeps* (4.3%). The receding phase had 15 species recorded and *Oreochromis andersonii* (43.9%) was still the most numerous species followed by *Coptodon rendalli* (41.9%), *Serranochromis angusticeps* (4.5%), *Tilapia sparrmanii* (2.9%) and *Pseudocrenilabrus philander* (1.8%).

In 2020 (see Appendix 2), most of the catch in numbers came from the rising phase, 21 584 individual fish were recorded and comprised of 18 fish species. The five most numerous fish species during the rising phase were *Oreochromis andersonii* (85.4 %), *Coptodon rendalli* (6.5%), *Hydrocynus vittatus* (4%), *Enteromius paludinosus* (1.5%), and *Enteromius unitaeniatus* (0.4%) respectively. During the high phase of the flood, 6 704 individual fish were recorded representing 23 fish species, of which *Coptodon rendalli* (41.6%), *Oreochromis andersonii* (40.1%), *Pharyngochromis acuticeps* (3.3 %), *Hydrocynus vittatus* (3.1%) and *Serranochromis macrocephalus* (1.9%) were the five most numerous fish species. The receding phase of the flood, 456 fish were recorded consisting of 8 fish species, with *Coptodon rendalli* (54.4%) being the most numerous species recorded, followed by *Oreochromis andersonii* (27.4%), *Serranochromis macrocephalus* (10.5%), *Pharyngochromis acuticeps* (1.5%) and *Serranochromis altus* (1.5%).

3.6.4 Catch composition of different fishing gears

3.6.4.1 Catch composition in plastic containers

During 2018 (see Appendix 4*Appendix 3*), a total of 15 fish species were recorded in plastic containers, constituting of 8 343 individual fish weighing 14.68 kg. According to index of relative importance (%IRI), the five most important species recorded were

Oreochromis andersonii (87.3%), *Pseudocrenilabrus philander* (9.3%), *Coptodon rendalli* (2.7%), *Serranochromis angusticeps* (2.4%) and *Hydrocynus vittatus* (1%).

During 2020 (see Appendix 5*Appendix 4*), a total of 3 fish species were caught in plastic containers, constituting of 312 individual fish weighing 0.773 kg. According to index of relative importance (%IRI), the five most important species recorded were *Oreochromis andersonii* (88.4%), *Coptodon rendalli* (11.5%), *Micropanchax johnstoni* (0.018%).

3.6.4.2 Catch composition in mosquito nets

During 2018 (see Appendix 6), a total of 23 fish species were recorded in mosquito nets, constituting of 6 748 individual fish weighing 14.68 kg. According to index of relative importance (%IRI), the five most important species recorded were *Oreochromis andersonii* (79.7%), *Hydrocynus vittatus* (10.1%), *Serranochromis angusticeps* (3 %), *Pseudocrenilabrus philander* (2.9%), *Coptodon rendalli* (2.5%).

During 2020 (see Appendix 7), a total of 21 fish species were caught in mosquito nets, constituting of 23 454 individual fish weighing 64.44 kg. According to index of relative importance (%IRI), the five most important species recorded were *Oreochromis andersonii* (82.8%), *Coptodon rendalli* (7.4%), *Hydrocynus vittatus* (4%), *Enteromius paludinosus* (2.9%) and *Serranochromis altus* (0.8%).

3.6.4.3 Catch composition in Hook and line

During 2018 (see Appendix 8), a total of 18 fish species were caught with hook and line, constituting of 875 individual fish weighing 15.00 kg. According to index of relative importance (%IRI), the five most important species recorded were *Coptodon rendalli* (55.1%), *Oreochromis andersonii* (39.7%), *Serranochromis angusticeps* (1.9 %), *Tilapia sparrmanii* (1.7%) and *Hydrocynus vittatus* (1%).

During 2020 (see Appendix *9*), a total of 15 fish species were caught in hook and line, constituting of 2 868 individual fish weighing 99.89 kg. According to index of relative importance (%IRI), the five most important species recorded were *Coptodon rendalli* (62.3%), *Oreochromis andersonii* (27%), *Serranochromis macrocephalus* (5.3%), *Pharyngochromis acuticeps* (2.2%) *Hydrocynus vittatus* (1.2%).

3.6.4.4 Catch composition in traditional traps

During 2018 (see Appendix 10), a total of 16 fish species were caught in traditional traps, constituting of 1175 individual fish weighing 4.32 kg. According to index of relative importance (%IRI), the five most important species recorded were *Oreochromis andersonii* (66.9%), *Coptodon rendalli* (16.4%), *Pseudocrenilabrus philander* (7.4%), *Enteromius bifrenatus* (3.1%) and *Serranochromis angusticeps* (2.9 %).

During 2020 (see Appendix 11), a total of 10 fish species were caught in traditional traps, constituting of 2 110 individual fish weighing 18.02 kg. According to index of relative importance (%IRI), the five most important species recorded were *Coptodon rendalli* (59.7%), *Oreochromis andersonii* (37.7%), *Pharyngochromis acuticeps* (2%), *Tilapia ruweti* (0.3%) and *Pseudocrenilabrus philander* (0.3%).

3.7 Body length distribution of fish caught on the Kamutjonga floodplain during the 2018 and 2020 flood cycle

Table: 8 Average body length, modal body length and range of body length of fish caught in the various fishing gears on the Kamutjonga floodplain during the 2018 and 2020 study period.

	Average length (mm)		**Modal length** (mm)		**Range** (mm)	
Fishing Gears	2018	2020	2018	2020	2018	2020
Plastic containers	55 ± 1.4	44.9 ± 0.9	50 -74	25 - 49	19 -130	25 - 83
Mosquito nets	57 ± 1.7	53.2 ± 1.5	50 -74	25 - 49	15 - 146	6 -180
Hook and line	93 ± 2.3	112.8 ±2.8	75 -99	100 -124	30 - 165	10 -272
Traditional traps	59.5 ± 1.8	76.9 ± 1.8	50 -74	75 -99	17 -150	7 -184

The body length of fish caught between plastic containers, mosquito nets, hook and line and traditional traps on the Kamutjonga floodplain differed significantly in 2018 and 2020 repectively (Kruskal-Wallis test; $P < 0.001$, df = 3). The average body length of fish caught in the different fishing gears was the highest in hook and line, followed by traditional traps, mosquito nets and plastic containers for both 2018 and 2020 flood cycle (Table: 8). In 2018, the modal length of fish caught between gears was the higher in Hook and line (75 -99), while plastic containers, mosquito nets and traditional traps had the same modal length (50 -74) (Figure 13). In 2020, Hook and line had the highest modal length of fish caught (100 -124), followed by (75 -99), platic containers and hook line with the same modal length (25 – 49) (Figure 14). In camparison between 2018 and 2020, the fish caught in plastic containers and mosquito nets in 2018 were larger than the fish caught in the same gears during the 2020 flood cycle (Mann-Whitney U =68605; $P < 0.001$ and Mann-Whitney U = 3288014; $P < 0.001$ respectively), while, the fish caught in hook and line and traditional traps in 2020 were larger than those caught in the same gear in 2018 (Mann-Whitney U = 3288014; $P < 0.001$ respectively).

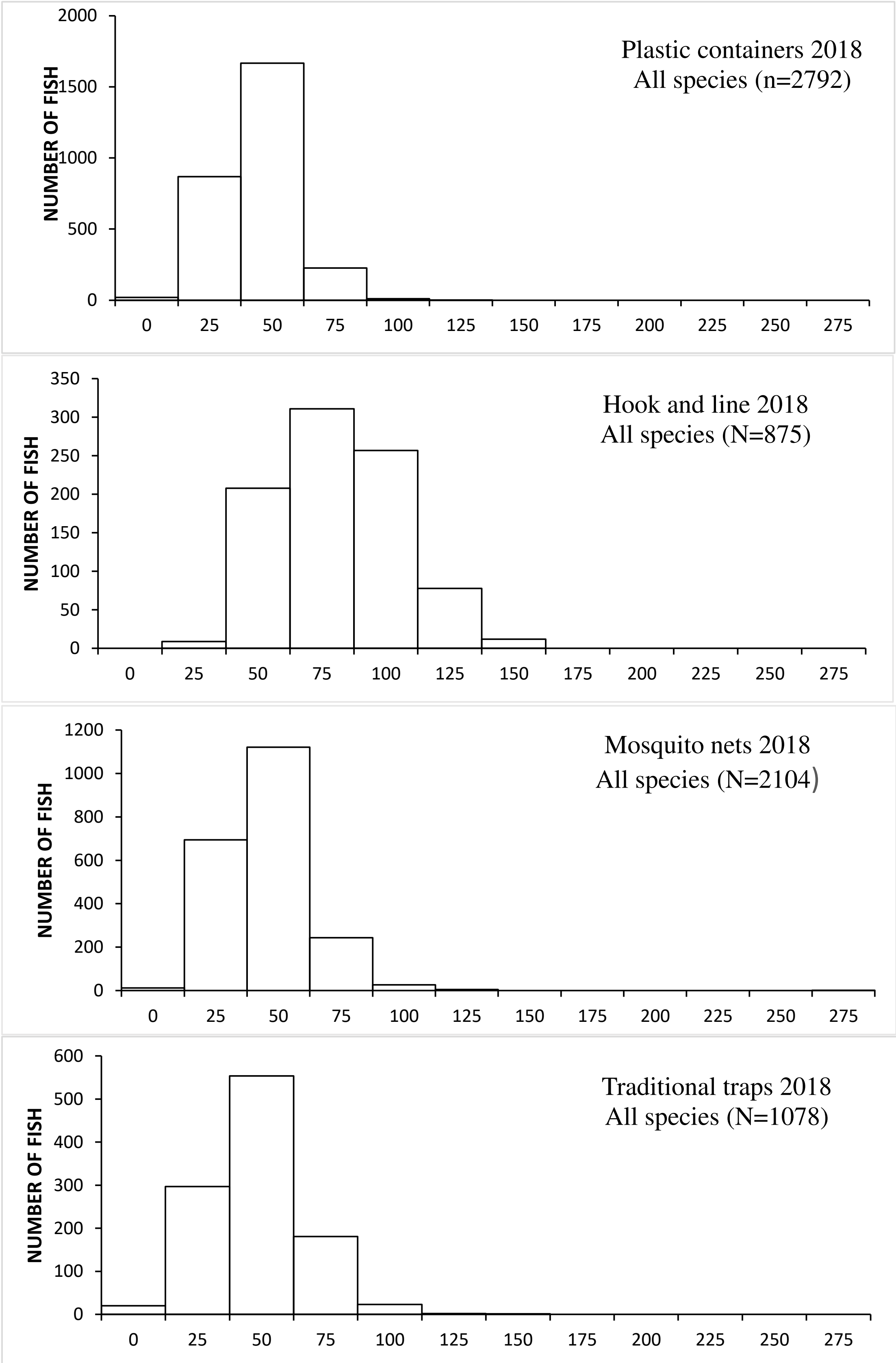

Figure 13: Length-frequency distribution of all fish sampled from plastic containers on the Kamutjonga floodplain of the Kavango river during 2018 and 2020 flooding season.

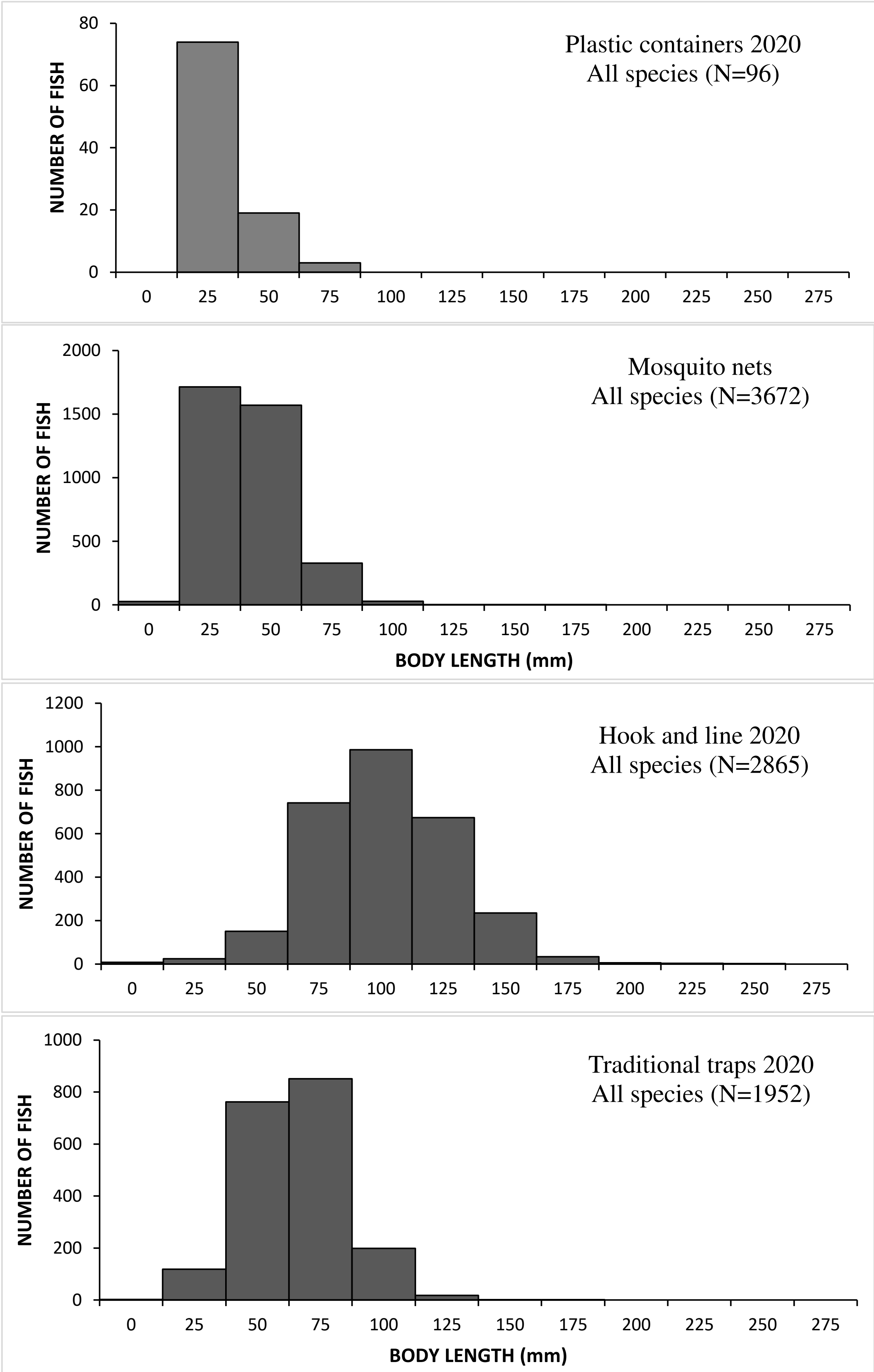

Figure 14: Length-frequency distribution of all fish sampled from plastic containers on the Kamutjonga floodplain of the Kavango river during 2018 and 2020 flooding season.

3.7.1 Body length distribution of fish caught in flood phases in 2018 and 2020

Table: 9 Average body length, modal body length and range of body length of fish caught in the different phases of the flood cycle on the Kamutjonga floodplain during the 2018 and 2020 study period.

	Average length (mm)		**Modal length** (mm)		**Range** (mm)	
Flood phases	2018	2020	2018	2020	2018	2020
Rising	57 ± 16	51 ± 15	50 - 57	25 - 54	18 - 272	6 -180
High	55 ± 18	77 ± 18	20 -74	75 - 99		7 - 272
Receding	88 ± 26	124 ± 27	75 -99	125 -149	18 - 164	10 - 238

The body length of fish caught between the rising, high and receding phase of the flood cycle differed significantly (Kruskal-Wallis test; $P < 0.001$, $df = 2$) in 2018 and 2020 repectively. In 2018, the average body length of fish caught in the different phases of the flood cycle was the highest during the receding phase (88 ± 26), followed by the rising phase (57 ± 16) were larger and the high (55 ± 18) respectively (Table: 9). In 2020, the average body length of fish caught in the different phases of the flood cycle was the highest during the receding phase (124 ± 27), followed by the high (77 ± 18) and rising phase (51 ± 15) respectively. In 2018, the receding phase had the highest modal length of fish caught (75 -99), followed by rising phase (50 – 57) and high phase (20 -74) (Figure 15). In 2020, the receding phase had the highest modal length of fish caught (125 -149), followed by high phase (75 - 99) and rising phase (25 - 54) (Figure 16).

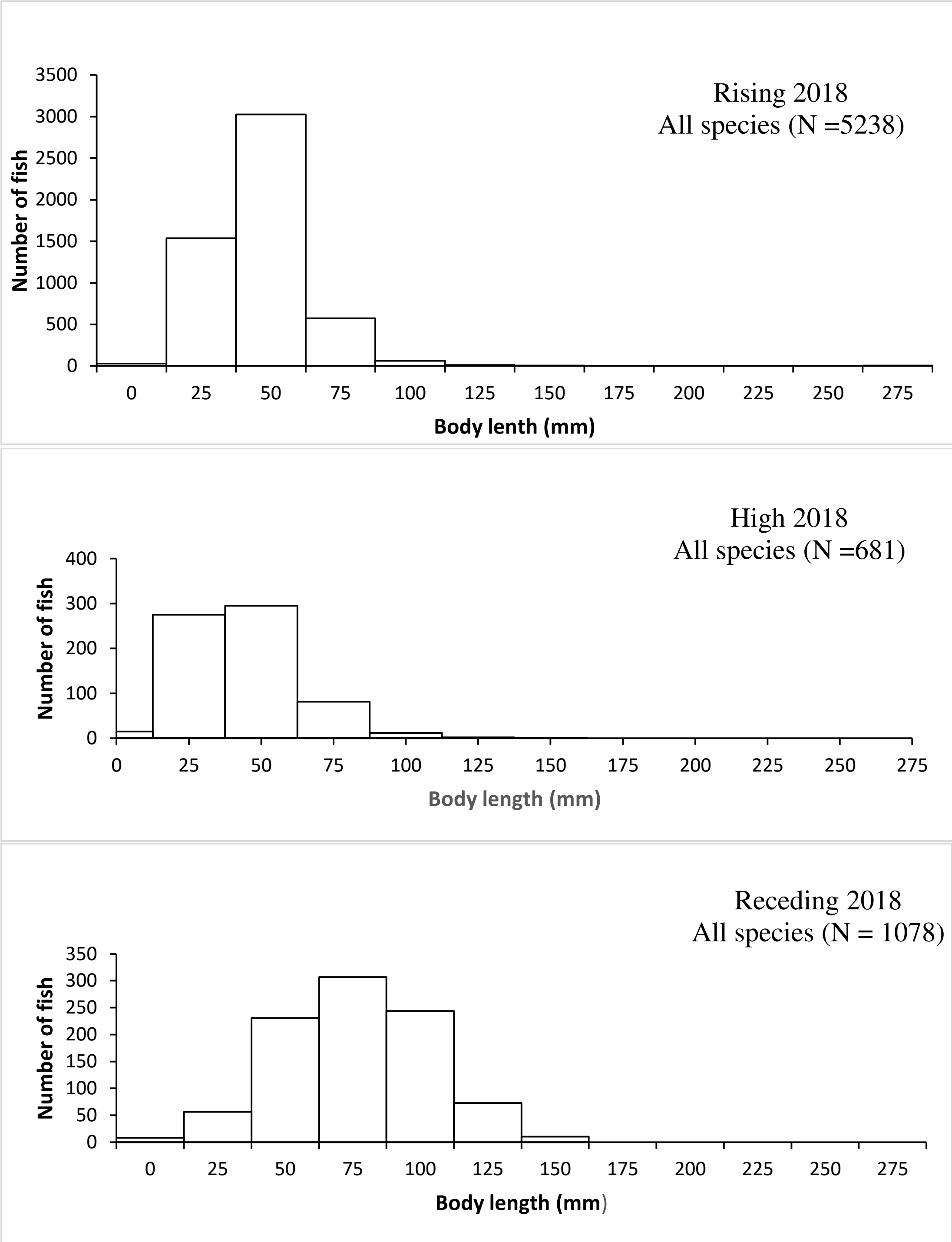

Figure 15: Length-frequency distribution of all fish sampled from in different phases of the flood cycle on the Kamutjonga floodplain of the Kavango River during 2018 flooding season.

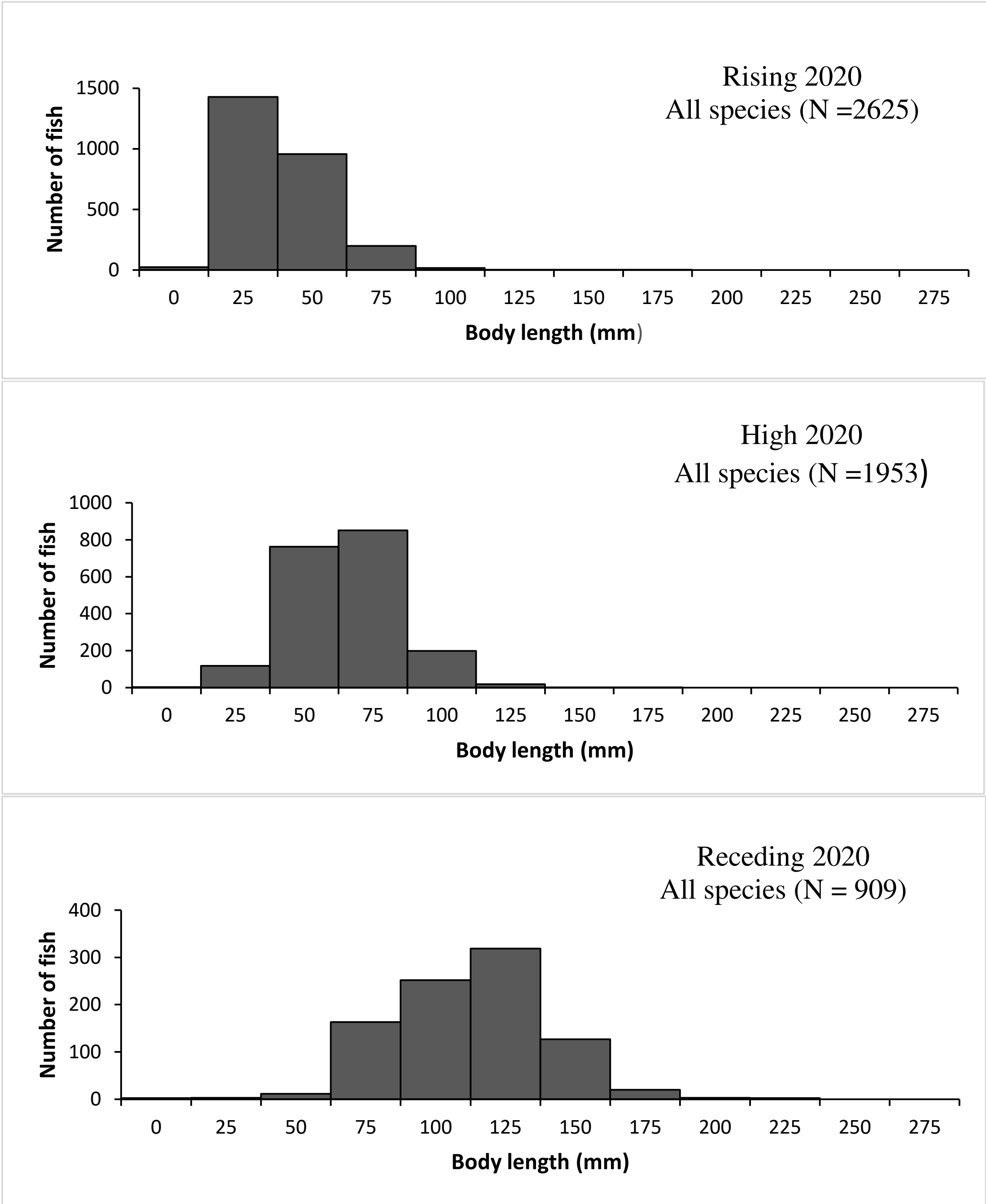

Figure 16: Length-frequency distribution of all fish sampled in different phases of the flood cycle on the Kamutjonga floodplain of the Kavango river during 2020 flooding season.

3.8 Catch per unit effort (CPUE) on the Kamutjonga floodplain

3.8.1 Catch per unit effort between gears in 2018

In 2018, CPUE by numbers/hour between the four fishing gears utilized on the Kamutjonga floodplains is illustrated in Figure 17a. In 2018, the CPUE by number between the gears varied significantly (Kruskal-Wallis test; $P < 0.001$, df = 3). The average CPUE by number/hour was the highest in mosquito nets (93 ± SE 30), consequently followed by plastic containers (12 ± SE 3), hook and line (10 ± SE 2), and traditional traps (7 ± SE 2). In addition, the CPUE by number/hour between two different gears showed that, mosquito nets had higher CPUE by number/hour than plastic containers (Kruskal-Wallis test; $P < 0.001$), mosquito nets had higher CPUE by number/hour than hook and line (Kruskal-Wallis test; $P < 0.001$), and mosquito nets had higher CPUE by number/hour than traditional traps ($P < 0.001$). Contrastingly, the CPUE by number/hour were similar between traditional trap and plastic containers (Kruskal-Wallis test; $P = 0.739$), traditional traps and hook and line (Kruskal-Wallis test; $P = 0.352$), and hook and line and plastic containers (Kruskal-Wallis test; $P = 0.759$).

The 2018 CPUE by kg/hour between the four fishing gears utilized on the Kamutjonga floodplains is illustrated in Figure 17b. In 2018, the CPUE by weight/hour between the gears varied significantly (Kruskal-Wallis test; $P < 0.001$, df = 3). The average CPUE by kg/hour was the highest in mosquito nets (0.21 ± SE 0.05 kg), followed by hook and line (0.17 ± SE 0.04 kg), traditional traps (0.03 ± SE 0.01 kg), and plastic containers (0.02 ± SE 0.00 kg).). In addition, the CPUE by kg/hour between two different gears showed that, mosquito nets had higher CPUE by kg/hour than plastic containers (Kruskal-Wallis test; $P < 0.001$), mosquito nets had higher CPUE by kg/hour than traditional traps ($P < 0.001$), traditional traps had higher CPUE by kg/hour than hook and line (Kruskal-Wallis test; P=0.002), hook and line had higher CPUE by kg/hour than plastic containers (Kruskal-Wallis test; P<0.001). Contrastingly, the CPUE by kg/hour were similar between mosquito nets and hook and line (Kruskal-Wallis test; P=0.295), traditional trap and plastic containers (Kruskal-Wallis test; P=0.295).

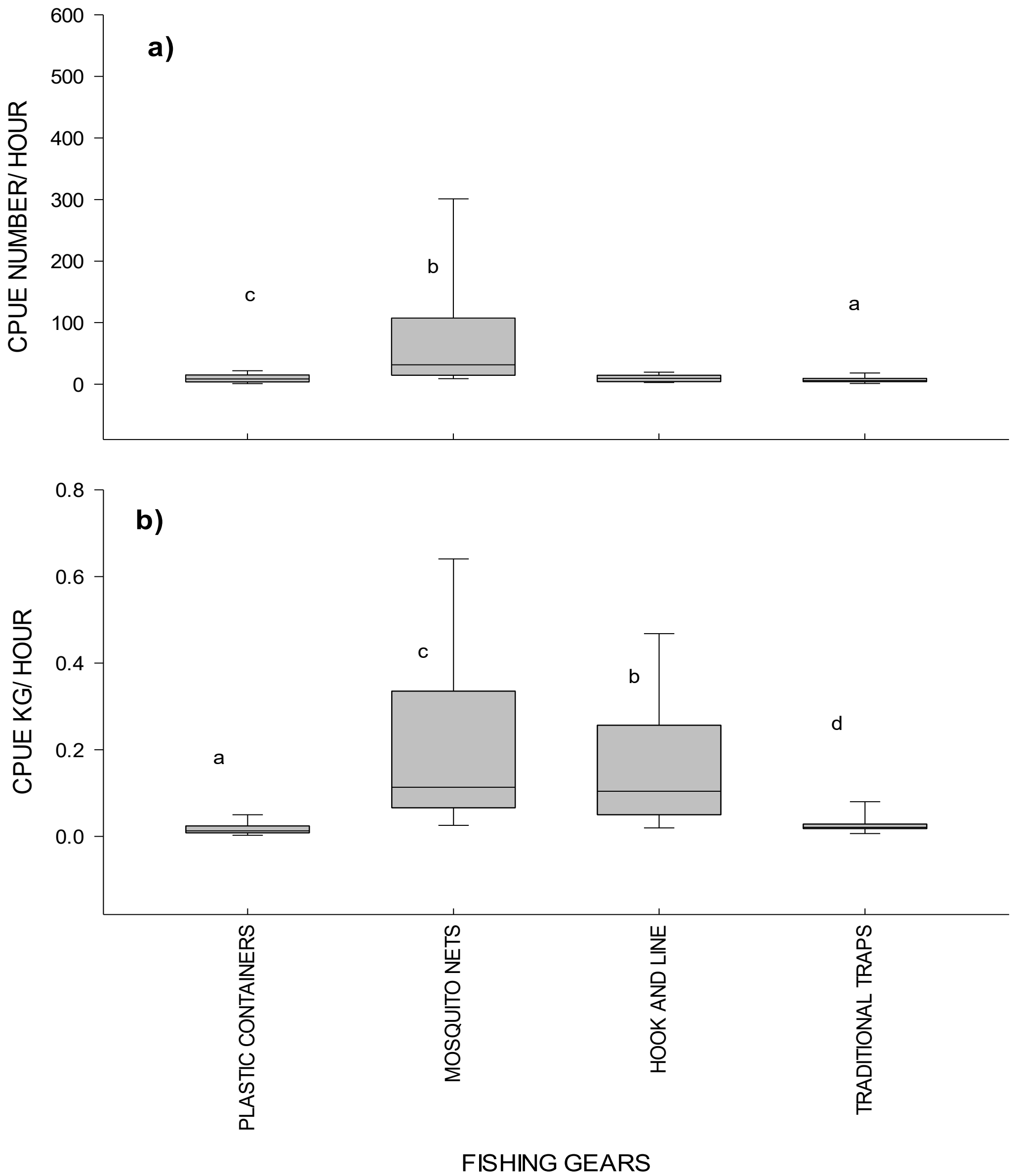

Figure 17: CPUE in number/hour (a) and weight (kg/hour) (b) for all fish species in the four different fishing gears on the Kamutjonga floodplain in 2018.

3.8.2 Catch per unit effort between gears 2020

The 2020 CPUE by numbers/hour between the four fishing gears utilized on the Kamutjonga floodplains is illustrated in Figure 18a. In 2020, the CPUE by number/hour between the gears varied significantly (Kruskal-Wallis test; $P < 0.001$, df = 3). The average CPUE by number/hour was the highest in mosquito nets (275 ± SE 62), followed by hook and line (18 ± SE 2), plastic containers (10 ± SE 0) and traditional traps (7 ± SE 1). In addition, the CPUE by number/hour between two different gears showed that, mosquito nets had higher CPUE by number/hour than plastic containers (Kruskal-Wallis test; $P = 0.014$), mosquito nets had higher CPUE by number/hour than hook and line (Kruskal-Wallis test; $P < 0.001$), and mosquito nets had higher CPUE by number/hour than traditional traps (Kruskal-Wallis test; $P < 0.001$), traditional trap had higher CPUE by number/hour than hook and line (Kruskal-Wallis test; $P = 0.007$). Contrastingly, the CPUE by number/hour were similar between traditional trap and plastic containers (Kruskal-Wallis test; $P = 0.278$), and traditional traps and hook and line (Kruskal-Wallis test; $P = 0.671$).

The 2020 CPUE by weight/hour between the four fishing gears utilized on the Kamutjonga floodplains is illustrated in Figure 18b. In 2020, the CPUE by weight/hour between the gears varied significantly (Kruskal-Wallis test; $P < 0.001$, df = 3). The average CPUE by weight/hour was the highest in mosquito nets (0.73 ± SE 0.17 kg), consequently followed by hook and line (0.63 ± SE 0.08 kg), traditional traps (0.06 ± SE 0.01 kg) and plastic containers (0.03 ± SE 0.00 kg). In addition, the CPUE by kg/hour between two different gears showed that, mosquito nets had higher CPUE by kg/hour than plastic containers (Kruskal-Wallis test; $P < 0.05$), mosquito nets had higher CPUE by kg/hour than traditional traps (Kruskal-Wallis test; $P < 0.001$), hook and line had higher CPUE by kg/hour than traditional traps (Kruskal-Wallis test; P <

0.001), and hook and line had higher CPUE by kg/hour than plastic containers (Kruskal-Wallis test; P < 0.003). Contrastingly, the CPUE by kg/hour were similar between mosquito nets and hook and line (Kruskal-Wallis test; P = 0.971), traditional trap and plastic containers (Kruskal-Wallis test; P = 0.753).

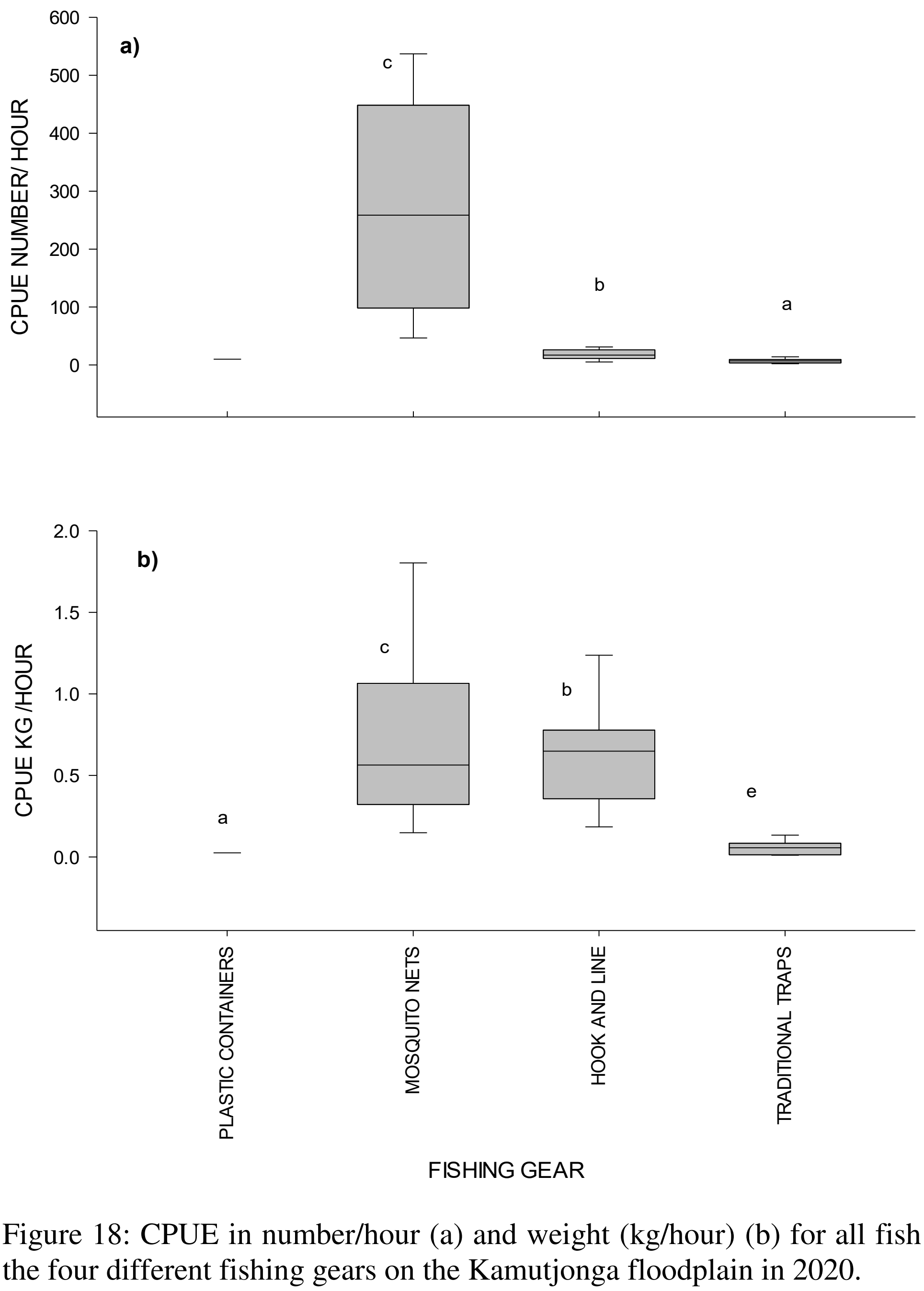

Figure 18: CPUE in number/hour (a) and weight (kg/hour) (b) for all fish species in the four different fishing gears on the Kamutjonga floodplain in 2020.

3.8.3 Comparison of Catch per unit effort in gears between 2018 and 2020

Table: 10 Catch per unit effort (number/hour and kg/hour) of different fishing gears utilized on the Kamutjonga floodplain in 2018 and 2020 flood cycle.

		Catch per unit effort (CPUE)	
Fishing gear		number/hour	kg/hour
Plastic containers	2018	12 ± SE 3	0.02 ± SE 0.00
	2020	10 ± SE 0.01	0.03 ± SE 0.00
Mosquito nets	2018	93 ± SE 30	0.21 ± SE 0.05
	2020	275 ± SE 62	0.73 ± SE 0.17
Hook and line	2018	10 ± SE 2	0.17 ± SE 0.04
	2020	18 ± SE 2	0.63 ± SE 0.08
Traditional trap	2018	7 ± SE 2	0.03 ± SE 0.01
	2020	7 ± SE 1	0.06 ± SE 0.01

The CPUE of fishing gears utilized on the Kamijonga floodplain in terms of numbers/hour and kg/hour are illustrated in Table: *10* above. The CPUE of fish caught in plastic containers between 2018 and 2020 was similar in terms of CPUE number/hour (Mann-Whitney U = 14.500; P = 0.929) and CPUE kg/hour (Mann-Whitney U = 20.00; P = 0.519). The CPUE by numbers/hour of fish caught with traditional traps during 2018 flooding season was similar to fish caught in 2020 flooding season (Mann-Whitney U = 207.00; P < 0.05). However, The CPUE by kg/hour of fish caught with traditional traps during 2018 flooding season was less than in 2020 flooding season (Mann-Whitney U = 305.00.00; P < 0.001). The CPUE of fish caught in mosquito net during 2018 flooding season was less than 2020 flooding season in terms of CPUE number/hour (Mann-Whitney U = 177.000; P = 0.002) and CPUE kg/hour (Mann-Whitney U = 181.000; P = 0.001). The CPUE of fish caught in hook and line during 2018 flooding season was also less than 2020 flooding season in terms of CPUE number/hour (Mann-Whitney U = 248.00; P < 0.01) and CPUE kg/hour (Mann-Whitney U = 305.00.00; P < 0.00).

3.9 Total fish catch estimates for the Kamutjonga floodplain during the 2018 and 2020 flood cycles

In this study, the total catch on the Kamutjonga floodplain during each flooding season was estimated based on the average catch per unit effort in kilograms or numbers (Ci/Ei) times the hours fished each day Hi and the number of gears Gi.

$$\text{Total estimated catch for fisher day} = \Sigma\ (Ci/Ei) \times (Hi \times Gi)$$

The total estimated catch was 150.53 kg in 2018 comprising of 44 932 individual fish. In 2020, the total estimated catch was 1 607 kg comprising of 144 306 individual fish (Table 11). The total catches were excessively higher in 2020 when compared to 2018 catches.

3.9.1 Total catch estimate in different phases of the flood cycle on the Kamutjonga floodplain

In 2018, the catch estimates by number in different phases of the flood cycle were higher during the rising phase (39 275 individual fish), followed by the receding phase (4 607 individual fish) and the high phase (1050 individual fish).Contrastingly, the catch estimate by weight (kg) in different phases of the flood cycle were higher during the rising phase (79.00 kg), followed by the receding phase (68.49 kg) and the high phase (2.99 kg).

In 2020, the catch estimates by number in the different phases of the flood cycle were higher during the high phase (57 472 individual fish), followed by the rising phase (50 453 individual fish), and the receding phase (9 389 individual fish). While, the catch estimate by weight (kg) in different phases of the flood cycle were higher during high phase (1 215.01 kg), followed by receding phase (415.25 kg), and the rising phase (123.65 kg).

3.9.2 Total catch estimate in different fishing gears utilized on the Kamutjonga floodplain

In 2018, the total catch estimate in the different fishing gears utilized on the Kamutjonga floodplain was the highest by number in mosquito nets (20 574 fish individuals), followed by plastic containers (19062 fish individuals), hook and line (3803 fish individuals) and traditional trap (1493 fish individuals). While, hook and line was the highest in total catch estimate by weight (71.11 kg), followed by mosquito nets (39.15 kg), plastic containers (35.08 kg) and traditional traps (5.19 kg). In 2020, the total catch estimate in different fishing gears utilized on the Kamutjonga floodplain was the highest by number in mosquito nets (63 160), followed by hook and line (38 756), traditional traps (8 808) and plastic containers (2 550). While, hook and line was the highest in total catch estimate by weight (1 302.76 kg), followed by mosquito nets (189 kg), traditional traps (103.28 kg) and plastic containers (6.63 kg) being the least.

Table 11: Total estimated catch per gear and per phase during the 2018 and 2020 flood cycles on the Kamutjonga floodplain.

			Fishing gears				
Phases	Year	Unit	Plastic containers	Mosquito nets	Hook and line	Traditional traps	Total
Rising	2018	n	18288	17263	683	396	36630
		kg	33.74	31.47	6.61	1.79	73.61
	2020	n	2300	48153	-	-	50453
		kg	5.92	117.67	-	-	123.59
High	2018	n	34	135	-	747	916
		kg	0.11	0.123	-	2.39	2.623
	2020	n	550	15451	29368	9096	54465
		kg	1.43	76.2	887.48	106.39	1071.5
Receding	2018	n	-	1487	3120	133	4740
		kg	-	3.98	64.5	0.37	68.85
	2020	n	-	-	9389	-	9389
		kg	-	-	415.28	-	415.28

4 Discussion

Freshwater fisheries in Namibia is closely related to a series of floodplain rivers in the north and northeastern parts of the country. The Kavango River system is one such river that has extensive floodplains. Many riparian communities exploit fish resources on the Kavango River to sustain their livelihood. This study focused on the exploitation of fish resources on the floodplains of the Kavango River, in particular the Kamutjonga floodplain. During the study period, the Kamutjonga floodplain received seasonal flooding of varying intensity, where the 2020 flood cycle was much larger (2.35 m peak) than the 2018 flood cycle (1.35 m peak). Seasonal floods are usually associated with a high abundance of fish production and riparian communities take the opportunity and exploit the fish resource (Mosepele, 2019; Simasiku & Mafwila, 2017). A total of 254 and 462 fisher days were recorded on the Kamutjonga floodplain during the 2018 and 2020 flood cycles, with an estimated catch of 150 kg and 1 607 kg, respectively. The fish caught on the Kamutjonga floodplain were mainly for personal consumption and for close family members referred to as subsistence fishing. Several other authors have highlighted that exploitation of fish resources on the Kavango river system was mainly for subsistence consumption, even though there have been reports of commercialization of the fish resources that is coupled with increased fishing pressure and leads to overexploitation of the fish resource (Hay et al., 2000; Hocutt & Johnson, 2001; Munwela, 2010; Sandlund & Tvedten, 1992; Tweddle & Hay, 2013).

In 2020, the estimated catch was much higher than the estimated catch during 2018. The higher estimated catch during the 2020 flood cycle was attributed to the higher flood during 2020 that lasted longer, resulting in more fisherdays as compared to the 2018 flood that was smaller with fewer fisherdays. In addition, the higher catches may have been attributed to the increased number of fisherdays as a consequence of the national lockdown measures that were put in place because of the Coronavirus. The 2020 flood cycle coincided with the national lockdown measures, which caused the shutting down of most of the economic activities, including schools, except for essential services. The lockdown measures resulted in an increased number of people in the village that migrated from town to the villages as they were not engaging in any economic activities which provided them with income and employment as a source of livelihood. In turn, more people in the village turned to the floodplain as a source of livelihood, mainly fishing as a source of food. This highlights the significance the floodplains have on riparian communities, especially during difficult times. Turpie, (2008a) had previously reported that the Zambezi/Chobe riverine fisheries, including floodplains, are fished opportunistically, mostly as a supplement to other livelihood activities. This implied that households mainly adopt a risk-spreading strategy to avoid the risk of starvation in bad years, where fishers do not only engage in one activity but rather engage in other activities to minimize the risk by maintaining a steady income and level of subsistence despite environmental variability. In addition, Simasiku (2019) emphasized that floodplain fishers on the Zambezi/Chobe are opportunistic and mainly fish for subsistence consumption. The riparian communities of Kamutjonga village turned to fishing as a buffer solution to the lost income and means of subsistence due to the national lockdown measures of the Coronavirus.

4.1 Gear utilization

During the study period, four different fishing gears were utilized to exploit the fish resources. These gears included: plastic containers, mosquito nets, traditional traps and hook and line. These fishing gears recorded on the Kamutjonga floodplain have been previously reported on the Kavango river system (Kangausaru, 2017; Munwela, 2010). The fishing gears recorded on the Kamutjonga floodplain were observed to be utilized in a succession pattern, where fishers employed different fishing gears at different depth levels. According to Kolding et al. (2016) and Mosepele (2014) the succession pattern of fishing gears at different depth levels was practised to adapt depending on the effectiveness of the fishing gear at different depth levels coupled with the fluctuating abundance of fish as a consequent of varying depth levels of the flood cycle. In addition, Turpie (2008) reported that different fishing gears preferred different stages of the flood because of the diverse range of habitats and ecological niches that are brought about by the rising and receding of the flood. Furthermore, Purvis (2002) indicated that a wide range of fishing gears and methods were only utilized when they were most effective to exploit fish on floodplains at varying levels of intensity.

The observation made during the study was that plastic containers and mosquito nets were utilized mostly during the rising phase of the flood and during the late stages of the receding phase, mainly when the flood level was lower. This was because it was easier to set and retrieve plastic containers at shallow levels of the floodplain when the current of the flood was at its minimum to avoid being washed away. Similarly, Van Der Waal (1991) reported of the use of funnels (plastic containers forms part of funnels) being used at shallow weedy bays, and weedy sand of the floodplains on the Kavango river system. Mosquito nets were also deployed at shallow habitats of the flood, where it involved active pursuit of fish into the gear, mostly done by two or more people. This fishing practise was mainly possible during low water as it was more difficult and most likely impossible to operate the gear during high water phase. In the same way, Bush et al. (2017) reported of the use of mosquito nets at shallow habitats to capture fish, mostly in floodplains.

During the high phase, the use of plastic containers and mosquito nets became difficult to utilize, and fishers changed gears and utilized traditional traps. Traditional traps were designed in such a way that they could be deployed in high water levels (above 1m) and withstand the pressure of the current. Van Der Waal (1991) described traditional trap (fish corral traps) as mat-like structures made of woody stems that were 80-100 cm long by 70-90 cm high and were sharpened at one end to drive them easily into a substrate in a concave shape. The gear had 10 -30 mm gaps between the stem to allow the entry of fish, and these gaps eased the pressure current of water on the gear without being washed away and it was for this reason that traditional traps were the preferred gear during the high water phase of the flood cycle.

Hook and line were also utilized during the high phase of the flood, mostly, this occurred when the high phase lasted for a longer period in the case of the 2020 flood cycle. Floodplains are known to be nursing and feeding grounds for newly spawned fish, and as the flood progressed, the fish grew to a relatively bigger size. In 2020, the high phase had relatively bigger sized fish (77 ± 18 mm SD) as compared to 2018 (55 ± 18 mm SD) because the high phase lasted longer in 2020 than in 2018, allowing fish to grow into bigger sized fish. In this case, hook and line were used in the high phase of the flood where fish were relatively bigger and could be caught by hook and line. Contrastingly, plastic containers and mosquito nets were also utilized during the later stages of the receding phase when the water levels were low, however, the practice was not as intense as in the rising phase mainly because the fish were bigger and could easily avoid these fishing gears.

The effectiveness of the fishing gears at different levels of the flood coupled with the preference of gear use by female and males determined the dominance of male and females in the different phases of the flood cycle. Females dominated the use of all the fishing gear utilized on the Kamutjonga floodplain (plastic containers, mosquito nets and traditional traps) except for hook and line. Abbott et al. (2003) and Van Der Waal (1991) had previously reported on the dominance of females using fish funnels and corral trap (in this study referred to as plastic containers and traditional traps respectively), while males dominated the use of hook and line. In addition, Abbott & Campbell, (2009) reported that mosquito nets are mostly utilized by women and children on the Zambezi river floodplain, which was similarly observed on the Kamutjonga floodplain. In accordance, females dominated the fishing during rising and high phase of the flood where plastic containers, mosquito nets and traditional traps are mostly utilized, while male fishers dominated the receding phase of the flood where hook and line is mostly utilized. In addition, the dominance of male fishers in the high phase in the case of the 2020 flood cycle, where the high phase lasted for a longer period.

4.2 Catch per unit effort

The fishing gear efficiency was expressed as catch per unit effort (CPUE) for all species caught per gear per hour in terms of numbers/hour or weight (kg/hour). According to the results, both flood cycles (2018 and 2020) had significant differences in the CPUE both by number and weight (kg) amongst the gears utilized in each flood cycle ($P<0.005$). Overall, mosquito nets had the highest CPUE in terms of numbers and weight compared to other gears. The high CPUE in mosquito nets is because of small mesh sizes and the method the gear is operated. The small size allows minimum escape of fish caught in the haul mainly juvenile and small-sized fish (average body length 57 ± 1.7 mm). The method in which the gear is operated maximizes the catch as school of juvenile and small-sized fish are chased towards the net. Large fish effectively sense and avoid the slow-moving pressure wave that a dragged fine-meshed seine causes (mosquito nets). However, juvenile and small sized fish cannot effectively sense the pressure wave the seine causes and cannot easily avoid the mosquito net as a fishing gear (Jones & Unsworth, 2020). Hook and line is the second highest in CPUE by number and weight for the two flooding cycles except the CPUE by number in the 2018 flood cycle. Hook and line had relatively low CPUE by number compared to mosquito net, however, hook and line had relatively similar CPUE by weight with mosquito net in both years. This was because hook and line caught relatively caught larger fish (average body length 93 ± 2.3 and 112.8 ±2.8 (2020)) compared to mosquito nets (average body length 57 ± 1.7 (2018) and 53.2 ± 1.5 (2020)), eventhough, hook and line caught much less fish than mosquito nets. Traditional traps and plastic containers caught smaller fish and less fish compared to the other two method of fishing. These passive gears are not designed to catch large fish. The CPUE in both numbers/hour and kg/hour of the gears utilized during the study period was higher during the 2020 flood cycle compared to the 2018 flood cycle. This was because of the larger flood cycle in 2020 as compared to 2018 with relatively smaller flood, where higher floods results in higher fish production (Hocutt & Johnson, 2001).

4.3 Catch composition

A total of 31 fish species were recorded from the four different fishing gears utilized on the Kamutjonga floodplain. This constitutes about 43% of the 72 fish species recorded on the entire Kavango river system. The catches recorded in this study were more than the 24 fish species recorded in 2012 by Simasiku & Mafwila (2017) along the littoral zones of the Kavango river-floodplain. Overall, the families Cichlidae and Cyprinidae dominated the catches along the Kamutjonga floodplain. Previously (Hocutt & Johnson, 2001; Kangausaru, 2017; Simasiku & Mafwila, 2017) reported dominance of Cichlidae and Cyprinidae on the floodplains of the Kavango River. Cichlidae family was dominated by *Oreochromis andersonii* and *Coptodon rendalli* respectively. In addition, *Oreochromis andersonii* and *Coptodon rendalli* dominated the entire catch composition during the study period. Moreover, *Oreochromis andersonii* dominated the catches in all the different phases of the flood cycle. The dominance of *Oreochromis andersonii* and *Coptodon rendalli* in terms of index of relative importance (%IRI) have been reported from the fishers catches on the Zambezi and Chobe Rivers and floodplains (Hay et al., 2020). Similarly, Mosepele, (2019) reported the same trend in species dominance on commercial fishers catches using gillnets in the Okavango delta. The *Enteromius* species were collectively the third dominant species caught on the Kamutjonga floodplain. Furthermore, they constituted the highest variety of fish species (8) caught by family (Cyprinidae) in this study.

4.4 Body length distribution of fish caught on the floodplain

The body length of fish caught during the study period ranged from 5 -270 mm. Hook and line were found to catch much bigger fish (average length 93 ± 2.3 mm SD and 112.8 ± 2.8 mm) when compared to other gears. Hook and line are known to be selective gears targeting specific sizes of fish (Munwela, 2010) and in this regard, the specific gear was used during the receding phase of the flood when the fish were of bigger sizes than during the rising phase of the flood. Plastic containers (average length 55 mm and 45 mm) and mosquito nets (average length 57mm and 53mm) that were commonly used during the rising phase of the flood, caught smaller sized fish (55.1± 1.4 mm SD and 44.9 ± 0.9 mm SD) compared to traditional taps (59.5 ± 1.8 mm SD). Traditional traps caught slightly bigger fish than plastic containers and mosquito nets as the fish had grown slightly bigger in the high phase. Most of the fish species caught on the floodplain were juvenile of larger fish species, while other fish species were from small sized fish species. The abundance of juvenile fish species on the Kavango floodplain during flooding season have also being reported by Hocutt & Johnson (2001) and Simasiku (2019). Juvenile fish species on floodplain rivers are subject to high mortality rates, and according to Welcomme, (1985), many factors influence high mortality rates in floodplain river systems, these include predation, competition, stranding or isolation, disease, and unfavourable hydrological conditions that includes extremes temperature and low dissolved oxygen as well as fishing. Thus, the natural mortality of juvenile fish species is usually high and by exploiting juveniles at the current level should not have any effect on the adult population.

4.5 Conclusion

Floodplain fisheries provides important fish resources to the riparian communities. This is evident from the results, where the riparian community took advantage of the seasonal abundance of fish on the floodplain by exploiting the resource as a food source. These fish provided the riparian community with essential proteins and micronutrients that supplement other means of subsistence. Fishing on the Kamutjonga floodplain is seasonal and on a part-time basis, while engaging in other livelihood activities. Fishers on the Kamutjonga floodplain used four different fishing gears to exploit the abundant fish resources. 31 of the 72 fish species found in the Kavango

River system were caught during the study. *Oreochromis andersonii* and *Coptodon rendalli* were the two most important fish species caught on the Kamutjonga floodplain. Most of the fish caught on the floodplain were mostly small sized and juvenile fish, where hook and line caught the much bigger fish compared to other gears. The CPUE in terms of numbers/hour and weight/hour (kg/hour) was significantly higher in mosquito nets when compared to other gears, while the other three gears had relatively lower CPUE. The CPUE by number/hour and weight (kg/hour) was higher during 2020 flood cycle than in 2018. In addition, the estimated catch was much more higher in 2020 than 2018. This was because of the large flood experienced on the floodplain during 2020 than 2018. Large flood supports high fish recruitment and production as the area of inundation are increased, which support important nursery habitats for fish and important source of food for riparian communities (Siziba et al., 2011). It is suggested that the seasonal harvesting of the Kamutjonga floodplain should be continuously monitored to ensure that managers are timely informed of any changes in fishing activities that might negatively impact the fish stocks and make management recommendation. A fishery reserve is recommended for the Kamutjonga floodplain, where fishers and communities are allowed to manage their own resources by setting up rules and regulation through the ministry of fisheries and marine resources in colleraboration with the tradional authority. If the fishery reserve is managed properly by the community, the fish resources on the Kamutjonga floodplain can be sustained.

4.6 Recommendation

- Most of floodplain fisheries lack reliable and sufficient scientific data. Continuous monitoring of floodplain fisheries recommended in order to build up reliable and sound scientific data that will enable fisheries biologists to make informed decision in managing the floodplain fishery
- Floodplains provide important habitats for fish as breeding, nursing and feeding grounds. The protection of floodplains is important to the absolute functioning of the floodplain. The Ministry of Fisheries and Marine Resources have limited resources for monitoring and control of the fishery. As such, fishery reserve is recommended for the Kamutjonga floodplain, where fishers and communities are allowed to manage their own resources by setting up rules and regulation through a fish reserve.
- Conduct further research on breeding, nursery, feeding and recruitment characteristics of fish species on the floodplain. This will enable a better understanding of the entire floodplain system and better management for sustainability of the fish resources.
- Small mesh sized nets gives fishers access to fish. However in terms of the inland fisheries act of 2003, small mesh sizes are not allowed, as they are regarded as unsustainable and destructive and a recipe of overfishing. More research needs to be conducted to determine the impact small mesh sized nets has on the fishery, more especially on floodplains.
- The Ministry of Fisheries and Marine Resources should provide necessary means of resources to conduct floodplain research activities.

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6 Appendices

Appendix 1. Ethical clearance certificate issued by the University of Namibia Ethics Committee to carry out the study.

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ETHICAL CLEARANCE CERTIFICATE

Ethical Clearance Reference Number: SOS-0021 Date: 25 October 2021

This Ethical Clearance Certificate is issued by the University of Namibia Ethics Committee (REC) in accordance with the University of Namibia's Research Ethics Policy and Guidelines. Ethical approval is given in respect of undertakings contained in the Research Project outlined below. This Certificate is issued on the recommendations of the ethical evaluation done by the ethics committee.

Title of Project: ASSESSMENT OF FISHERS' CATCHES ON THE KAMUTJONGA FLOODPLAIN ALONG THE KAVANGO RIVER, NAMIBIA

Student: DEON CAIN TIYEHO

Student Number: 201024519

Supervisor(s): DR. CLINTON HAY (University of Namibia);
DR. TOR NAESJE (Norwegian Institute for Nature Research);
DR. FRANCOIS JACOBS (Min. of Fisheries and Marine Resources)

Centre for Research Services

Take note of the following:

1. Any significant changes in the conditions or undertakings outlined in the approved Proposal must be communicated to the ethics committee. An application to make amendments may be necessary.
2. Any breaches of ethical undertakings or practices that have an impact on ethical conduct of the research must be reported to the ethics committee
3. The Principal Researcher must report issues of ethical compliance to the ethics committee (through the Chairperson) at the end of the Project or as may be requested by the ethics committee
4. The ethics committee retains the right to:

i) Withdraw or amend this Ethical Clearance if any unethical practices (as outlined in the Research Ethics Policy) have been detected or suspected,

ii) Request for an ethical compliance report at any point during the course of the research.

The ethics committee wishes you the best in your research.

Dr. Zivayi Chiguvare (Chairperson Ethics Committee)

Prof. Davis Mumbengegwi (Head, Multidisciplinary Research)

Appendix 2. Catch composition of fish species in different phases of the flood cycle on the Kamutjonga floodplain in 2020.

	Seasonal flood cycle					
	Rising		High		Receding	
Species	No	% No	No	% No	No	% No
Oreochromis andersonii	18430	85.4	2687	40.1	125	27.4
Coptodon rendalli	1397	6.5	2790	41.6	248	54.4
Pharyngochromis acuticeps	-	-	221	3.3	7	1.5
Hydrocynus vittatus	857	4	211	3.1	7	1.5
Serranochromis macrocephalus	-	-	126	1.9	48	10.5
Serranochromis altus	-	-	155	2.3	-	-
Tilapia sparrmanii	-	-	80	1.2	9	2
Enteromius paludinosus	327	1.5	55	0.8	-	-
Enteromius unitaeniatus	94	0.4	46	0.7	-	-
Enteromius fasciolatus	106	0.5	27	0.4		
Serranochromis altus	41	0.2	-	-	-	-
Enteromius poechii	62	0.3	8	0.1	-	-
Labeo cylindricus	158	0.7	-	-	-	-
Enteromius radiatus	26	0.1	18	0.3	-	-
Micropanchax johnstoni	29	0.1	19	0.3	-	-
Tilapia ruweti	24	0.1	44	0.7	-	-
Enteromius bifrenatus	14	0.1	4	0.1	-	-
Enteromius barnardi	8	0	123	1.8	-	-
Clarias gariepinus	5	0	4	0.1	-	-
Pseudocrenilabrus philander	2	0	68	1	-	-
Clarias ngamensis	2	0	1	0	5	1.1
Synodontis nigromaculatus	-	-	4	0.1	-	-
Schilbe intermedius	2	0	3	0	-	-
Labeo cylindricus			9	0.1	-	-
Serranochromis altus	-	-	-	-	7	1.5
Oreochromis macrochir	-	-	1	0	-	-
Total	21584	100	6704	100	456	100

Appendix 3. Catch composition of fish species in different phases of the flood cycle on the Kamutjonga floodplain in 2018.

	Seasonal flood cycle					
	Rising		**High**		**Receding**	
Species	**No**	**% No**	**No**	**% No**	**No**	**% No**
Oreochromis andersonii	11415	72.9	354	47.8	430	43.9
Hydrocynus vittatus	1383	8.8	-	-	1	0.1
Pseudocrenilabrus philander	1222	7.8	103	13.9	18	1.8
Coptodon rendalli	373	2.4	99	13.4	411	41.9
Serranochromis angusticeps	583	3.7	32	4.3	44	4.5
Tilapia sparrmanii	-	-	-	-	28	2.9
Pharyngochromis acuticeps	-	-	-	-	6	0.6
Enteromius radiatus	169	1.1	12	1.6	4	0.4
Enteromius bifrenatus	130	0.8	84	11.3	25	2.6
Tilapia ruweti	70	0.4	29	3.9	3	0.3
Oreochromis macrochir	-	-	-	-	1	0.1
Tilapia sparrmanii	36	0.2	9	1.2	-	-
Enteromius poechii	40	0.3	2	0.3	1	0.1
Enteromius barnardi	75	0.5	1	0.1	-	-
Enteromius fasciolatus	74	0.5	-	-	-	-
Brycinus lateralis	-	-	-	-	2	0.2
Micropanchax johnstoni	52	0.3	8	1.1	-	-
Sargochromis greenwoodi	8	0.1	-	-	-	-
Enteromius paludinosus	9	0.1	-	-	-	-
Serranochromis macrocephalus	2	0	-	-	5	0.5
Enteromius unitaeniatus	6	0	-	-	-	-
Micralestes acutidens	7	0	-	-	-	-
Serranochromis altus	3	0	-	-	-	-
Enteromius eutaenia	4	0	3	0.4	-	-
Ctenopoma multispine	1	0	-	-	-	-
Labeo lunatus	1	0	-	-	-	-
Hepsetus cuvieri	-	-	-	-	1	0.1
Clarias gariepinus	1	0	5	0.7	-	-
Total	15664	100	741	100	980	100

Appendix 4. Catch composition in plastic containers on the Kamutjonga floodplain in 2018.

Species	No	% No	Weight (kg)	% Weight	FRQ	% FRQ	IRI	% IRI
Oreochromis andersonii	6806	81.6	12.303	83.9	25	96.2	15909	87.3
Pseudocrenilabrus philander	774	9.3	0.493	3.4	21	80.8	1021	5.6
Coptodon rendalli	145	1.7	0.603	4.1	22	84.6	495	2.7
Serranochromis angusticeps	263	3.2	0.401	2.7	19	73.1	430	2.4
Hydrocynus vittatus	89	1.1	0.448	3.1	12	46.2	190	1
Enteromius bifrenatus	101	1.2	0.033	0.2	15	57.7	83	0.5
Tilapia ruweti	46	0.6	0.232	1.6	3	11.5	25	0.1
Enteromius radiatus	30	0.4	0.069	0.5	6	23.1	19	0.1
Tilapia sparrmanii	20	0.2	0.053	0.4	7	26.9	16	0.1
Enteromius poechii	25	0.3	0.017	0.1	10	38.5	16	0.1
Enteromius barnardi	27	0.3	0.011	0.1	8	30.8	12	0.1
Enteromius fasciolatus	6	0.1	0.004	0	4	15.4	1	0
Micropanchax johnstoni	9	0.1	0.001	0	1	3.8	0	0
Micralestes acutidens	1	0	0.001	0	1	3.8	0	0
Enteromius unitaeniatus	1	0	0	0	1	3.8	0	0
Total	8343	100	14.669	100	-	-	18218	100

Appendix 5. Catch composition in plastic containers on the Kamutjonga floodplain in 2020.

Species	No	% No	Weight(kg)	% Weight	FRQ	% FRQ	IRI	% IRI
Oreochromis andersonii	281	90.1	0.67	86.7	1	100	17672	88.4
Coptodon rendalli	30	9.6	0.103	13.3	1	100	2293	11.5
Micropanchax johnstoni	1	0.3	0	0	1	100	35	0.2
Total	312	100	0.773	100	-	-	20000	100

Appendix 6. Catch composition in mosquito nets on the Kamutjonga floodplain in 2018.

Species	No	% No	Weight(kg)	% Weight	FRQ	% FRQ	IRI	% IRI
Oreochromis andersonii	4251	63	11.367	77.4	19	86.4	12128	79.7
Hydrocynus vittatus	1201	17.8	0.919	6.3	14	63.6	1531	10.1
Serranochromis angusticeps	273	4	0.533	3.6	13	59.1	454	3
Pseudocrenilabrus philander	421	6.2	0.362	2.5	11	50	435	2.9
Coptodon rendalli	179	2.7	0.847	5.8	10	45.5	383	2.5
Enteromius radiatus	141	2.1	0.278	1.9	9	40.9	163	1.1
Enteromius bifrenatus	43	0.6	0.075	0.5	5	22.7	26	0.2
Micropanchax johnstoni	46	0.7	0.019	0.1	6	27.3	22	0.1
Enteromius fasciolatus	68	1	0.06	0.4	3	13.6	19	0.1
Enteromius barnardi	48	0.7	0.03	0.2	4	18.2	17	0.1
Tilapia sparmanii	18	0.3	0.067	0.5	4	18.2	13	0.1
Tilapia ruweti	18	0.3	0.035	0.2	3	13.6	7	0
Enteromius paludinosus	9	0.1	0.027	0.2	3	13.6	4	0
Enteromius poechii	7	0.1	0.007	0	4	18.2	3	0
Enteromius unitaeniatus	5	0.1	0.008	0.1	4	18.2	2	0
Enteromius eutaenia	7	0.1	0.004	0	3	13.6	2	0
Micralestes acutidens	6	0.1	0.012	0.1	1	4.5	1	0
Hepsetus cuvieri	1	0	0.013	0.1	1	4.5	0	0
Serranochromis macrocephalus	1	0	0.005	0	1	4.5	0	0
Sargochromis greenwoodi	1	0	0.005	0	1	4.5	0	0
Serranochromis altus	2	0	0.002	0	1	4.5	0	0
Labeo lunatus	1	0	0.003	0	1	4.5	0	0
Clarias gariepinus	1	0	0.002	0	1	4.5	0	0
Total	6748	100	14.681	100	-	-	15211	100

Appendix 7. Catch composition in Mosquito nets on the Kamutjonga floodplain in 2020.

Species	No	% No	Weight(kg)	% Weight	FRQ	% FRQ	IRI	% IRI
Oreochromis andersonii	19516	83.2	52.781	81.9	9	90	14861	82.8
Coptodon rendalli	1466	6.3	4.55	7.1	10	100	1331	7.4
Hydrocynus vittatus	1032	4.4	1.83	2.8	10	100	724	4
Enteromius paludinosus	382	1.6	2.631	4.1	9	90	514	2.9
Serranochromis altus	171	0.7	0.613	1	9	90	151	0.8
Enteromius unitaeniatus	140	0.6	0.304	0.5	8	80	86	0.5
Enteromius barnardi	131	0.6	0.437	0.7	6	60	74	0.4
Enteromius fasciolatus	133	0.6	0.162	0.3	7	70	57	0.3
Enteromius poechii	70	0.3	0.237	0.4	6	60	40	0.2
Labeo cylindricus	167	0.7	0.248	0.4	3	30	33	0.2
Enteromius radiatus	44	0.2	0.12	0.2	6	60	22	0.1
Micropanchax johnstoni	47	0.2	0.034	0.1	6	60	15	0.1
Pseudocrenilabrus philander	41	0.2	0.075	0.1	5	50	15	0.1
Tilapia ruweti	25	0.1	0.106	0.2	3	30	8	0
Pharyngochromis acuticeps	51	0.2	0.217	0.3	1	10	6	0
Enteromius bifrenatus	18	0.1	0.014	0	4	40	4	0
Clarias gariepinus	5	0	0.038	0.1	2	20	2	0
Schilbe intermedius	4	0	0.006	0	3	30	1	0
Tilapia sparrmanii	8	0	0.02	0	1	10	1	0
Oreochromis macrochir	1	0	0.01	0	1	10	0	0
Clarias ngamensis	2	0	0.005	0	1	10	0	0
Total	23454	100	64.439	100	-	-	17944	100

Appendix 8. Catch composition in hook and line on the Kamutjonga floodplain in 2018.

Species	No	% No	Weight (kg)	% Weight	FRQ	% FRQ	IRI	% IRI
Coptodon rendalli	406	46.4	8.258	55	16	100	10145	55.1
Oreochromis andersonii	338	38.6	5.151	34.3	16	100	7297	39.7
Serranochromis angusticeps	40	4.6	0.484	3.2	7	43.8	341	1.9
Tilapia sparrmanii	24	2.7	0.256	1.7	11	68.8	306	1.7
Hydrocynus vittatus	29	3.3	0.41	2.7	5	31.3	189	1
Serranochromis macrocephalus	6	0.7	0.135	0.9	4	25	40	0.2
Pharyngochromis acuticeps	6	0.7	0.078	0.5	4	25	30	0.2
Enteromius poechii	7	0.8	0.043	0.3	3	18.8	20	0.1
Sargochromis greenwoodi	5	0.6	0.067	0.4	2	12.5	13	0.1
Tilapia ruweti	3	0.3	0.026	0.2	1	6.3	3	0
Oreochromis macrochir	1	0.1	0.053	0.4	1	6.3	3	0
Enteromius radiatus	3	0.3	0.013	0.1	1	6.3	3	0
Pseudocrenilabrus philander	3	0.3	0.008	0.1	1	6.3	2	0
Brycinus lateralis	2	0.2	0.004	0	1	6.3	2	0
Serranochromis altus	1	0.1	0.007	0	1	6.3	1	0
Ctenopoma multispine	1	0.1	0.007	0	1	6.3	1	0
Total	875	100	15.001	100	-	-	18395	100

Appendix 9. Catch composition in hook and line on the Kamutjonga floodplain in 2020.

Species	No	% No	Weight(kg)	% Weight	FRQ	% FRQ	IRI	% IRI
Coptodon rendalli	1711	59.7	55.2	55.3	21	100	11492	62.3
Oreochromis andersonii	706	24.6	27.725	27.8	20	95.2	4988	27
Serranochromis macrocephalus	174	6.1	7.657	7.7	15	71.4	981	5.3
Pharyngochromis acuticeps	109	3.8	1.978	2	15	71.4	413	2.2
Hydrocynus vittatus	42	1.5	1.382	1.4	16	76.2	217	1.2
Tilapia sparrmanii	76	2.6	1.288	1.3	11	52.4	206	1.1
Serranochromis altus	32	1.1	0.895	0.9	12	57.1	115	0.6
Clarias gariepinus	3	0.1	2.874	2.9	2	9.5	28	0.2
Clarias ngamensis	6	0.2	0.37	0.4	2	9.5	6	0
Synodontis nigromaculatus	4	0.1	0.466	0.5	1	4.8	3	0
Pseudocrenilabrus philander	3	0.1	0.029	0	2	9.5	1	0
Schilbe intermedius	1	0	0.015	0	1	4.8	0	0
Tilapia ruweti	1	0	0.012	0	1	4.8	0	0
Total	2868	100	99.891	100	-	-	18450	100

Appendix 10. Catch composition in traditional trap on the Kamutjonga floodplain in 2018.

Species	No	% No	Weight(kg)	% Weight	FRQ	% FRQ	IRI	% IRI
Oreochromis andersonii	605	51.5	2.681	62.1	12	100	11357	66.9
Coptodon rendalli	142	12.1	0.684	15.8	12	100	2792	16.4
Pseudocrenilabrus philander	134	11.4	0.156	3.6	10	83.3	1251	7.4
Enteromius bifrenatus	95	8.1	0.037	0.8	7	58.3	521	3.1
Serranochromis angusticeps	63	5.4	0.131	3	7	58.3	489	2.9
Hydrocynus vittatus	65	5.5	0.384	8.9	2	16.7	240	1.4
Tilapia ruweti	34	2.9	0.084	2	5	41.7	202	1.2
Clarias gariepinus	5	0.4	0.09	2.1	2	16.7	42	0.2
Enteromius radiatus	11	0.9	0.003	0.1	4	33.3	34	0.2
Enteromius poechii	4	0.3	0.006	0.1	4	33.3	16	0.1
Tilapia sparrmanii	9	0.8	0.045	1.1	1	8.3	15	0.1
Sargochromis greenwoodi	2	0.2	0.017	0.4	2	16.7	9	0.1
Micropanchax johnstoni	5	0.4	0	0	1	8.3	4	0
Enteromius barnardi	1	0.1	0.001	0	1	8.3	1	0
Total	1175	100	4.319	100	-	-	16972	100

Appendix 11. Catch composition in traditional trap on the Kamutjonga floodplain in 2020.

Species	No	% No	Weight(kg)	% Weight	FRQ	% FRQ	IRI	% IRI
Coptodon rendalli	1228	58.2	11.056	61.4	12	92.3	11036	59.7
Oreochromis andersonii	739	35	6.247	34.7	13	100	6970	37.7
Pharyngochromis acuticeps	68	3.2	0.499	2.8	8	61.5	369	2
Tilapia ruweti	42	2	0.081	0.5	3	23.1	56	0.3
Pseudocrenilabrus philander	26	1.2	0.067	0.4	4	30.8	49	0.3
Tilapia sparrmanii	5	0.2	0.013	0.1	3	23.1	7	0
Clarias gariepinus	1	0	0.035	0.2	1	7.7	2	0
Hydrocynus vittatus	1	0	0.019	0.1	1	7.7	1	0
Total	2110	100	18.018	100	-	-	18491	100