Consequences of calamities and their management: The case of COVID-19 pandemic and flooding on inland capture fisheries in Kenya

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ABSTRACT

During the period February to June 2020, heavy rainfall caused increases in levels and flooding in many lakes in East Africa. This coincided with the COVID-19 pandemic. These calamities affected ecosystems and livelihoods, especially of fishers who depend on fisheries as their only source of livelihood. This study examined the effects of COVID-19 and flooding on the major inland capture fisheries in Kenya to illustrate the effect of such calamities on vulnerable communities to guide interventions. Socioeconomic data were collected across the fish value chains during the peak of COVID-19 pandemic and flooding in Kenya from May to early June 2020. The measures put in place to contain COVID-19 pandemic notably dusk to dawn curfew (66%) and lock-downs (28%) in major cities that act as main fish markets were cited as the main factors that influenced fishing and fishing trade. Negative consequences reported included livelihood losses from the COVID-19 pandemic. Reduced fishing time and trips as well as a decline in consumables such as boat fuel resulted in low fish catches. Although COVID-19 pandemic affected livelihoods, the fish stocks benefited from reduction in fishing effort. Similarly flooding led to livelihood and material losses but positively impacted on stocks through expansion of fish breeding and nursery areas. The respondents recommended that governments should have disaster preparedness programs in place to address such calamities. There is also need for more detailed research on calamities that are increasing in frequency to provide information and data to guide policy and interventions.

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Introduction

The outbreak of Covid-19 was first identified in Wuhan, China in December 2019 and subsequently spread to many countries of the world. The World Health Organization declared it a Public Health Emergency of International Concern on 30 January, and a pandemic on 11 March 2020 (UN News, 2020). By 1st June 2020, 6.22 million people worldwide had been infected with more than 373,032 deaths (JHU, 2020). In Kenya, the first case of COVID-19 was reported on 12th March 2020 (Anadolu Agency News, 2020). Subsequently, the number of COVID-19 cases in the country increased and by 9th June 2020 a total of 2989 people had been infected (MoH News, 2020). The Kenya government instituted measures to reduce the spread of COVID-19 and minimize causalities. These included restricting international travel,

cessation of movement from some cities including the capital city of Nairobi, imposing curfews, social distancing and closure of areas of mass gathering such as schools and places of worship, and dusk to dawn curfews (Africa Press Office, 2020). These measures, and specifically the cessation of movement to cities that are the main fish markets, curfews and social distancing affected fishing trips and duration, disrupted the fish value chain and affected the livelihoods of fishers.

During the same period, the African great lakes region experienced floods that were manifested by increases in lake levels and overflowing of banks that would affect natural resources and livelihoods (Obando et al., 2016; Kohfeld and Harrison, 2000). There was increased support from the donor community and the Kenya government to address the challenges posed by COVID-19, but very little of this was channelled to cushion the fisheries sector (UN News, 2020; Welsh, 2020).

Riparian communities in the African Great Lakes are marginalized, vulnerable, and highly susceptible to the rapid impact of

social economic effects of mitigative measures such as those put in place to contain of COVID-19 (FAO, 2020; CFFA, 2020) and floods (Njiru et al., 2012). This is because lakes and reservoirs are important income and employment generators in developing nations as they stimulate the growth of a number of subsidiary industries and are a high quality source of cheap and nutritious food besides being a foreign exchange earner for riparian communities and lacustrine stakeholders (Hamerlynck et al., 2011; Aura et al., 2019; Nyamweya et al., 2020). More importantly, inland capture fisheries are a source of livelihood for a large section of an economically disadvantaged population in rural and peri-urban communities including women and young people (Dugan et al., 2006; Gangadhar, 2011; Njiru et al., 2019). The importance of fish as a source of comparatively cheap animal protein for people in the tropics, especially the most vulnerable groups, and the need for sufficient water to sustain fisheries can hardly be overemphasized (Welcomme, 2008). Fisheries occupy a significant place in the socioeconomic development of many countries (Woodhead et al., 2018; Njiru et al., 2012; 2019). For example, Kenya's fishery sector generally contributes about 4.7% of the country's Gross Domestic Product (GDP) (Mulatu et al., 2018). Fishers also often have limited livelihood options.

Management of inland lake fisheries face many challenges such as increased fishing pressure, invasive species, loss of biodiversity, environmental degradation, access and ownership issues, ecological changes, climate change, inadequate information and unharmonised policies (LVFO, 2015; Nyamweya et al., 2020). The concurrent emergence and consequences of COVID-19 and floods in Kenya put the fisheries productivity in crisis (CFFA, 2020; FAO, 2020). There is limited information on the effect of COVID-19 on inland aquatic systems and fishery livelihoods (Africa Press Office, 2020; FAO, 2020) to guide putting in place present and future mitigation and adaptation measures.

The influence of water level fluctuations on fisheries production has been widely studied in rivers, lakes and reservoirs (Welcomme, 1970; Hamerlynck et al., 2011; Kolding et al., 2016). These changes tend to affect productivity and the timing and area of breeding, food availability, catchability, expansion of shallow productive inshore areas, cage culture establishments (Kolding and van Zwieten, 2012; Gownaris et al., 2015; Musinguzi et al., 2019). Studies on Lakes Chad, Mweru, Mweru wa Ntipa and Chilwa reported variation in yield and species composition with lake level (Lévêque, 1995; Kolding et al., 2016). Currently, in Kenya, flooding in Lakes Baringo and Bogoria have been reported to displace thousands of people, disrupt several livelihood activities and social infrastructure, erode farmlands, and threaten cross-contamination between the two lakes which are in close proximity (BBC News, 2020). Evaluation of water level fluctuations in relation to fishery production and livelihoods provide useful information for resource management.

There is limited information on the impacts of calamities like Covid-19 and flooding on fishers to guide intervention measures. This study was therefore undertaken to contribute to that information as a case study. The objective of the study was to examine the consequence of the measures put in place to contain the spread of COVID-19 pandemic and flooding in Kenya to guide interventions to sustain livelihoods of affected communities.

Methods

Study area

The study was undertaken on Kenyan major lakes, namely, Victoria, Turkana, Baringo and Naivasha (Fig. 1). The lakes experienced increases in water levels causing widespread flooding that affected lakes-side communities and infrastructure especially of fishers. This was exacerbated by emergence of Covid-19 pandemic and the measures taken to control its spread. Lake fisheries in are important sources of livelihood providing food and employment (Kimani et al., 2018). Inland capture fisheries contribute >75% of Kenya's total fish production, currently at about 150,000 tonnes valued at about USD $190 million. The principal fishery is that of Lake Victoria with a 5-year average production of about 90,000 tonnes landed and valued at about USD $90 million (Ongore et al., 2018; Aura et al., 2020).

Lake Victoria is the world's largest tropical lake (68,800 km[2)] with a catchment area of 193,000 km^2, a shoreline of 3,440 km, average depth of 40 m and a maximum depth of 80 m with 82% of the water input coming from rainfall and 80% of the loss through evaporation. It has ten major inflowing rivers and one outflow. It produces about one million tons of fish valued at USD 400 annually, which provides employment to 200,000 fishers and up to 700,000 along the value chain.

Lake Turkana is Kenya's largest lake (6,405 km^2) located wholly in Kenya. It lies in a closed basin at 365 m above sea level with a mean and maximum depth of 31 m and 115 m respectively. It receives over 90% of its annual water input from one permanent river (Omo) that flows into the lake from Ethiopia. The lake is endorheic with no surface outlet. The water budget is a balance between river inflow and evaporation, which has made the lake to become increasingly saline. The lake's average annual fish production is highly influenced by water level changes. It is estimated to produce 7,000 tonnes per annum valued at USD $1.6 million (Long'ora et al., 2015) supporting about 7000 fishers and 6500 fish traders and transporters.

Lake Baringo, a Ramsar site, is a Rift valley lake with a surface area of 130 km^2, which varies greatly due to climatic variation (Källqvist et al., 1987). It has a mean depth of 5.6 m and three river inlets but no visible outlet save for suspected underground seepage (Aloo, 2002). The lake has an annual production of 263 tonnes of fish with an ex-vessel value of USD $250,000.

Lake Naivasha is also a Ramsar site within an urban setting. It surface area varies between 120 km^2 and 150 km^2 in the dry and wet seasons (Harper, 1992; Hickley et al., 2008). Its mean depth varies between 4 m and 6 m. Two tributaries feed the lake and its fisheries are influenced by changes in the lake water levels (Kitaka et al., 2002; Harper and Mavuti, 2004). An annual quantity of 1,063 tons of fish valued at USD $1. 4 million are landed by total of 50 fishing crafts licensed to operate with an average of 150 fishers per month.

Data collection

Data collection was conducted from May to early June 2020 at the peak of COVID-19 and flooding around Kenyan major lakes. Primary data collection included a socio-economics survey on perceptions and attitudes of purposively selected categories of stakeholders at the lake landing sites while secondary data was on lake levels was acquired from the United States Department of Agriculture (USDA)'s website and the Kenya Water Resource Authority (WRA). The categories of respondents included: input providers (boat builders and engine repairers); producers (fishers); middlemen (fish traders and processors); ancillary service providers (transporters and community health workers); and managers (Beach Management Units' officials). These categories were expected to provide credible information because they were directly involved in fisheries activities.

Data on the attitude to consequence of flooding and the interventions to contain Covid-19 were obtained using a semi-structured questionnaire with a 3-point likert scale rating. The
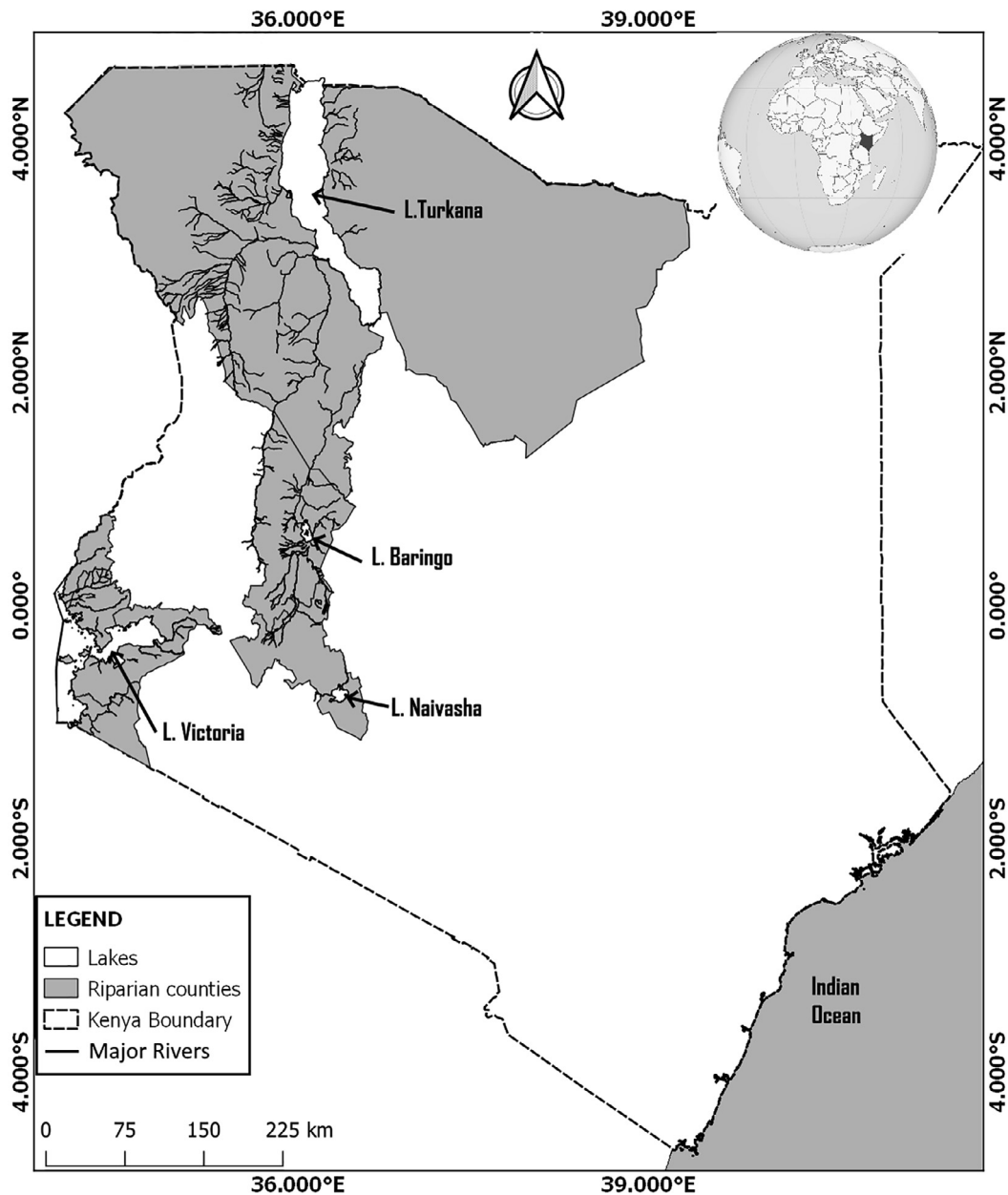
Fig. 1. Major Kenyan lakes, their basins.

consequences were rated as "A little" (<34% losses), "Much" (34–66% losses) or "very much" (>66% losses). Purposive sampling was applied because it is useful in situations where there is need to reach a targeted sample quickly and where sampling for proportionality is not the primary concern.

The data on changes in lake levels for Lakes Victoria, Turkana and Naivasha associated with flooding were obtained from the United States Department of Agriculture (USDA) website (https://ipad.fas.usda.gov/) while that for Lake Baringo were obtained from Water Resource Authority (WRA), but were only available for the year 2017 and during the peak of flooding period in 2020. The lake levels are monitored daily by WRA. These daily readings were compiled into monthly averages, which are referenced to a benchmark set in 1960 s to quantify the degree of flooding.

The changes in fish landing and prices before and after flooding and Covid-19 were obtained by comparing data collected between 2009 and 2017 before (before 14th March 2020) and during (after 14th March 2020) using the Electronic Fish Market Information System (EFMIS). EFMIS is an ICT (Information and Communication Technology Authority) pilot project, being implemented around Lake Victoria in Kenya based on mobile phones to provide information on landings in terms of species and prices at fish landing sites and markets (Aura et al., 2019).

Data analyses and interpretation

Quantitative socioeconomics data were subjected to descriptive analyses, and the qualitative data from open-ended questions to thematic analyses were used to triangulate results. The trend of the lake level was forecasted at 95% confidence interval using the Auto Regressive Integrated Moving Average (ARIMA) model for time series data and for predicting future points in the series (Hyndman and Khandakar, 2008; Asteriou and Hall, 2011). The EFMIS data was used to compare landings and prices for major commercial fish species before and during flooding and COVID-19 (Aura et al., 2019).

Microsoft Excel 2016 was used for data entry and cleaning while SPSS version 21 (SPSS Inc., Chicago, IL, USA) and R version 4.0.0 (R Core team, 2020) were used for statistical analyses. Variation in the parameters were compared per lake. Descriptive statistics were used to show the ranges and means over the period. The statistical significance level was set at an alpha of 0.05.

Validation of socioeconomics data

The EFMIS data was used for validation of the socioeconomics field data. This is because the EFMIS platform is extensively used on Lake Victoria which accounts for > 90% of fish production in Kenya (Aura et al., 2020). The magnitude of production from Lake Victoria makes its fishery have a strong influence on the demand and supply of fish on both domestic and international markets.

Results and discussion

Demographic and characteristics of the fish value chain actors

A total of 336 respondents were interviewed across the four lakes. The respondents were mainly fishers and fish traders (80%, n = 260) and was dominated by males (52%, n = 171). A fisher in this context is a person directly involved in fishing (Lwenya et al., 2006). The perception of respondents' indicate that they were adversely affected by both floods (92%, n = 290) and the COVID-19 (94%, n = 306) pandemic (Table 1). A recent study on the effect of Covid-19 pandemic on small-scale coastal communities who dealt in tilapia species reported similar setback (Bennett et al., 2020). Most (71%, n = 118) of the fishers, traders and processors who were affected by the pandemic and flooding dealt in tilapia species. Tilapia fish dominate the African menu due to its preference owing to good taste, fast growth and adaption to tropical climate, including Kenyan lakes and are among the dominant species on many inland fisheries in Africa (Njiru et al., 2006; 2012).

Lake level rise and flooding

The Kenyan major inland lake levels had a five-year general trend of rise and decline scenario, but with an overall rise from the year 2010 (Fig. 2). This could be attributed to the domination of runoffs from inlets in conjunction with increased precipitation that has occurred since early 2020. The study could not clearly forecast Lake Baringo's future water levels due to limited availability of long-term trend data, although, from the previous literature, the lake has been known to experience rising lake levels especially during heavy precipitation (Aloo, 2002).

On the other hand, Lake Naivasha's estimation variance was high; hence, the study could not robustly predict the future rise in water level points due to limited long-term data for the time series. Nonetheless, Lake Turkana is predicted to experience water level rise in the coming decade, and this could exacerbate the undesirable impacts of flooding that have already been experienced so far by dependent livelihoods. The lake level rise in Lake Victoria, which coincided with the two rainy seasons from March to May (long rains) and from October to December (short rains), is still projected to increase in the next 5 years.

From the socioeconomics survey, many fishers and traders reported that they had suffered from floods due to loss of homes, business and farmland, drowning of colleagues and relations, destruction of fishing infrastructure and flooding of landing sites. These alongside the predicted increase in precipitation and the associated rise in water level, illustrates the need to adhere to fisheries and environmental regulations (i.e. no settlements within 100 m from the highest water mark or on riparian zones) to minimize the effect of floods on riparian communities that may have encroached into these nominal waterways' reserves. In addition climate warming over Africa has intensified since the 1970s (Hulme et al., 2010) and IPCC (2013) has predicted that climate warming will be accompanied by increases in precipitation in the East African region. The flood being experience could be partly due to this, and there is need to develop adaptation and mitigation measures to reduce its impact on resources and livelihoods.

Effects of Covid-19 and flooding on inland fisheries

The study showed that all fisheries related occupations in the lakes examined registered substantial livelihood and material losses from the COVID-19 pandemic and floods (Table 2), although the pandemic effects were more extensive (many people) while the flooding effects were more intensive (more losses). Fish traders and processors were more affected by COVID-19 while fishers and BMU officials by floods. This finding could be attributed to the fact that COVID-19 regulations mainly affected markets where traders and processors operate while floods mainly impacted on fishing infrastructure and adjacent infrastructure where BMUs and fishers operate from or live. As such, losses from the pandemic were mainly on livelihoods whereas losses from floods were mainly on physical assets and infrastructure (Electronic Supplementary Material (ESM) Plates 1 and 2).

Table 1
Community perception on the effect of flooding and Covid-19 prevention measures (n = 336).

		Flooding (%)			COVID-19 (%)		
		A little	Much	Very much	A little	Much	Very much
Female		6	26	69	5	9	86
	BMU official	33	0	67	0	0	100
	Community Health Worker	0	100	0	0	0	100
	Fish processor	4	42	54	4	7	89
	Fish trader	6	21	73	6	10	84
	Fisher	0	23	77	8	0	92
	Transporter	0	100	0	0	100	0
Male		10	29	61	6	20	73
	BMU official	10	20	70	0	33	67
	Boat builder	0	50	50	0	50	50
	Fish processor	0	50	50	0	33	67
	Fish trader	21	50	29	12	28	60
	Fisher	7	24	68	6	15	79
	Fisheries Manager	100	0	0	50	50	0
	Out-board Engine repair	0	0	100	0	0	100
	Transporter	0	27	73	0	25	75
Grand Total		**8**	**27**	**65**	**6**	**15**	**79**
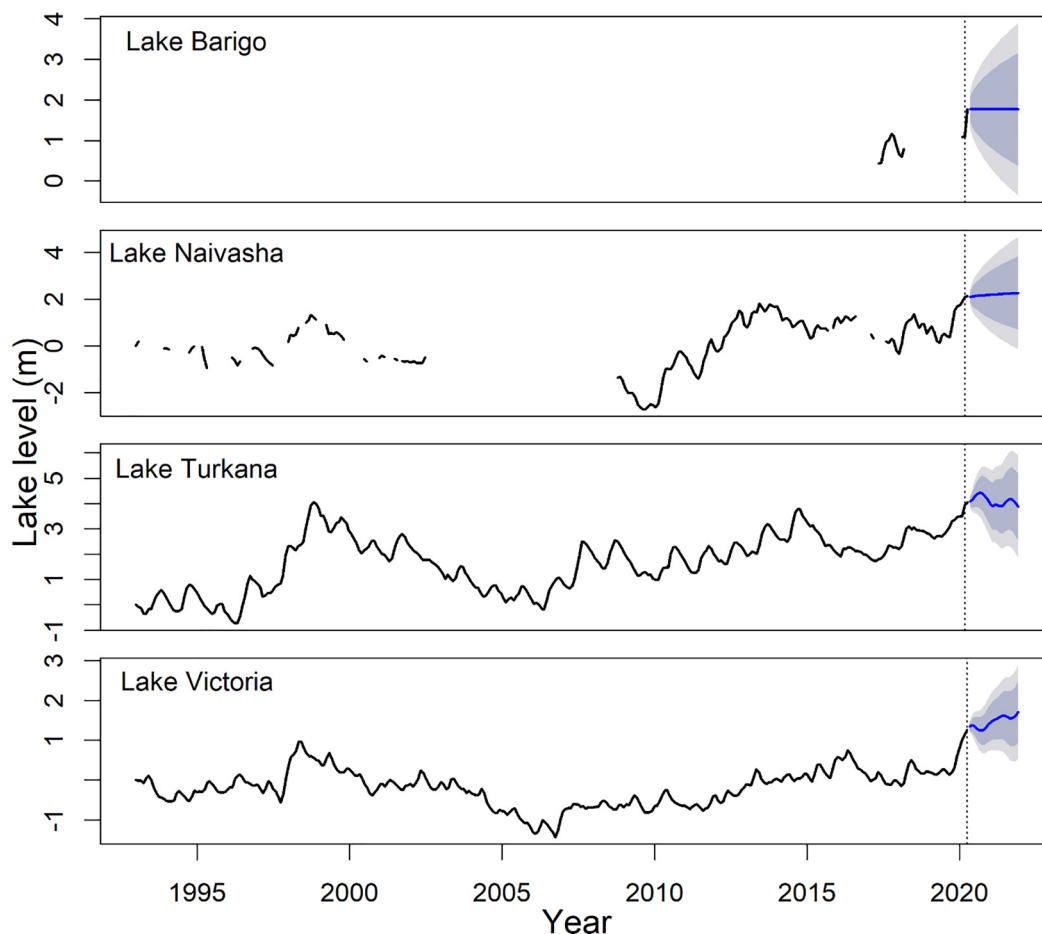
Fig. 2. Time series of lake levels for the major Kenyan lakes and modelled forecasts levels using the Auto Regressive Integrated Moving Average (ARIMA). The absence of a continuous trend depict lack of data. The middle trend of the forecast after the year 2020 shows the forecast of water level points, whereas, the grey shades indicate either the rise or decline of lake levels in relation to the current trend at a 95% confidence level.

The COVID-19 pandemic containment regulations impacted fishing and fish trade in all the freshwater lakes examined, for instance, dusk to dawn curfew (66%, n = 128), lock-down to major markets such as Nairobi and Mombasa (28%, n = 55), sanitary measures (3%, n = 6), and the rest being social distancing and curtailment of non-essential services. The sanitary measures had the highest impact in Lake Victoria while the curfew had most impact in all the other lakes (Table 3). This study was in agreement with others that noted that socioeconomic aspects and life in developing countries has been affected by hampering movements and connectivity (e.g., Béné et al., 2010; Béné and Friend, 2011; Immanuel, 2020).

The fishers reported fishing time to have been reduced (76%, n = 116) as well as fishing trips per week from an average of

Table 2
Magnitude of loss (Mean ± SD USD) incurred in the past one month from COVID-19 and floods per across occupations involved in the fisheries value chains of Kenyan major lakes.

Occupations	Sample size n	COVID-19 Mean ± SD	FLOODS Mean ± SD
BMU official	13	28.6 ± 26.3	2,482.4 ± 1550
Fish processor	33	80.7 ± 91.2	515.4 ± 378.7
Fish trader	136	163.5 ± 515.2	644.5 ± 345.1
Fisher	124	45.3 ± 61.4	3,670.3 ± 805.7
Transporter	13	29.3 ± 18.2	695.4 ± 440.3
Total	**319**	**94.2 ± 329.1**	**2,362.8 ± 581.7**

seven to five trips (n = 103) due to the COVID-19 pandemic. The reduction in fishing time and trips were occasioned by the dusk to dawn (1900 h – 0500 h) curfew. In addition, during the pandemic, there was a notable decline in the average crew (fishing inputs) and boat fuel (consumable) used in fishing activities resulting into a cross-cutting decline in catch quantities and prices (Fig. 3). The decline in fish prices is attributed to closure of major markets in the cities under lock-down, resulting in market glut within the nearby markets. The relatively difficult economic conditions also resulted into lower prices owing to reduced purchasing power of potential fish consumers. A significant reduction in fishing effort and inputs would significantly impact the socio-economic status of the already poor small-scale fishers (Béné and Friend, 2011; Freduah et al., 2017). While the current study did not emphasize the positive impacts of the Covid-19 on fisheries, it is expected that the pandemic would offer relief from any over-fishing through reduction in fishing effort.

Many fishers and traders reported that they had suffered very intense loss from floods mainly due to loss of homes, business and farmland, drowning of colleagues and relations, destruction of fishing infrastructure and sub-immersion of landing sites (Fig. 4). These, alongside forecast of future water level rise of lakes, calls for the need to adhere to fisheries and environmental regulations such as the 100 m setback to minimize the effect of floods on riparian communities that may have encroached into waterways' reserves. On a positive side, floods have been reported to enhance

Table 3
Proportions of respondents who perceived that the different COVID-19 control measures affected the fisheries, by lake (%).

	Curfew	Curtailment of non-essential services	Lock-down	Sanitary measures	Social distancing	Other
Baringo	83.3	2.8	2.8	8.3	0.0	2.8
Kisumu	37.0	0.0	55.6	7.4	0.0	0.0
Naivasha	60.2	0.0	39.8	0.0	0.0	0.0
Turkana	83.3	0.0	9.5	0.0	4.8	2.4
Average	66.3	0.5	28.5	2.6	1.0	1.0
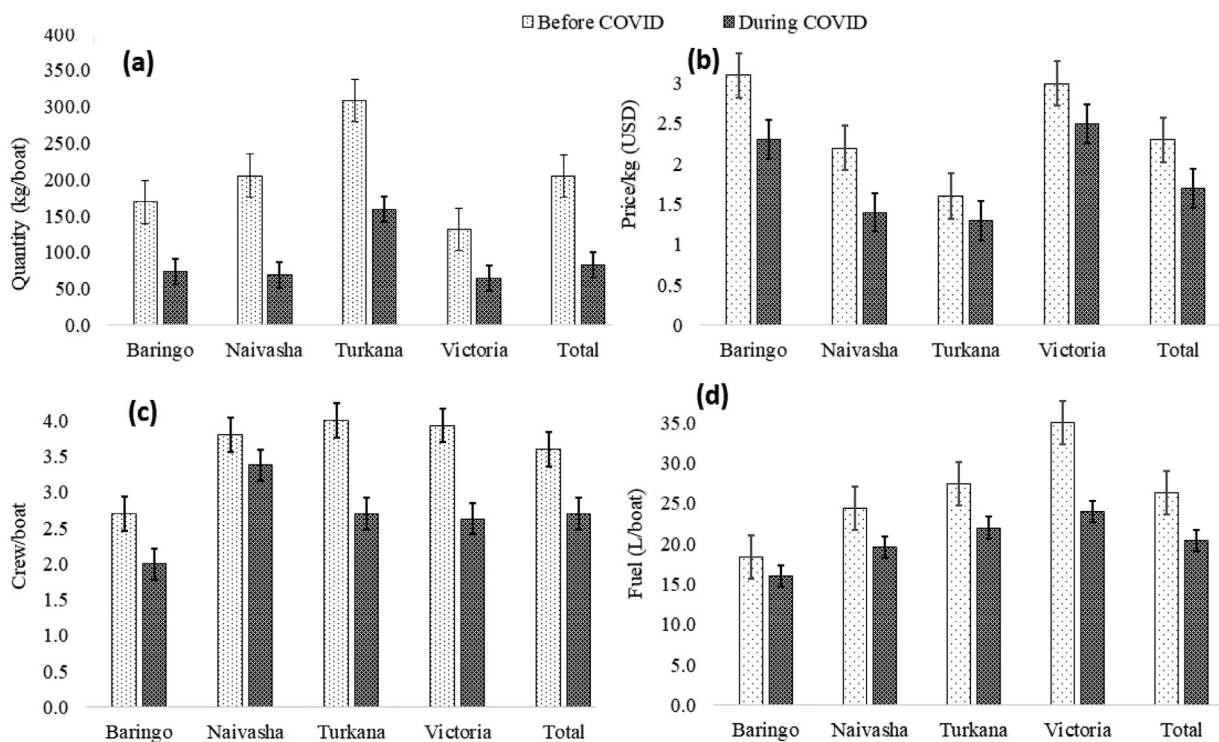
Fig. 3. Respondents' perceptions of impacts on fishing dynamics (mean ± SE) across major Kenyan lakes on: (a) Quantity of fish caught, (b) Price of fish, (d) Number of fishing crew, and (c) Boat fuel consumption.
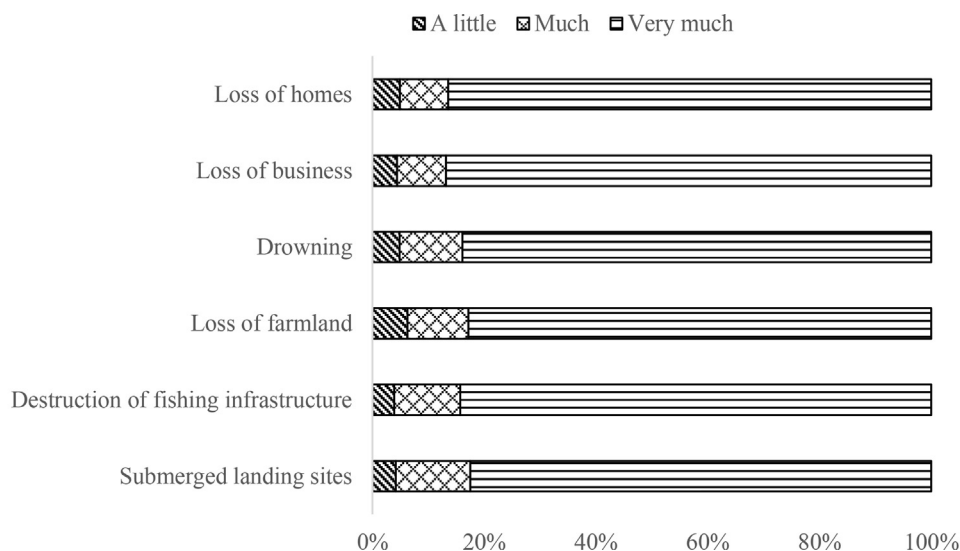
Fig. 4. Proportions of different categories of respondents who perceived the effects of floods, as being little, much, or very much, in major Kenyan lakes (%).

recruitment of some fishes especially inshore commercially important tilapias (Welcomme, 1970).

Validation of socioeconomics data and intervention measures

There was close agreement between the EFMIS data collected before and that of the current study. Only dagaa (small cyprinids) recorded higher prices during COVID-19 and flooding (Fig. 5). Unlike dagaa, Nile perch prices were highest before COVID-19 pandemic than during the pandemic. Nile perch is mainly an export fishery with European Union being an important market for Nile perch fillets and the far East Nations (China, Hong Kong and India) being important destinations for Nile perch maws from Lake Victoria (Marshall and Mkumbo, 2011). The introduction of internal and external travel restrictions, lockdowns and curfews affected movement of Nile perch and its products in and out of Kenya thereby affecting both internal and external markets (Béné et al., 2010; Agboola et al., 2018; Rajeev and Nagendran, 2020).

A fluctuating trend was exhibited for Lake Victoria tilapia in the major landing sites and markets. This could be related to disruption of market because of movement restrictions from some towns such as Nairobi, which has been the major market (Aura et al., 2019). A similar scenario was noted when China imposed lockdowns and travel restrictions (Tester, 2020; Dao, 2020). In this case, the demand for luxury seafood declined and markets collapsed for Canadian and American lobsters, Australian crayfish, Vietnamese shrimp and many other fisheries (Taunton and Cropp, 2020). In Homa Bay County on Lake Victoria, the price for tilapia was high during COVID-19 pandemic, probably due to high demand and very low quantities or supply that could not be supported from other parts of the lake and neighbouring countries was the case before COVID-19 crisis. Tilapia is the most valued fish delicacy in Kenya with increasing demands (Njiru et al., 2019). It however had low prices during COVID-19 pandemic in Siaya County (Lake Victoria) probably due to the availability of cage culture nearby, which supplements wild tilapia (Aura et al., 2018).
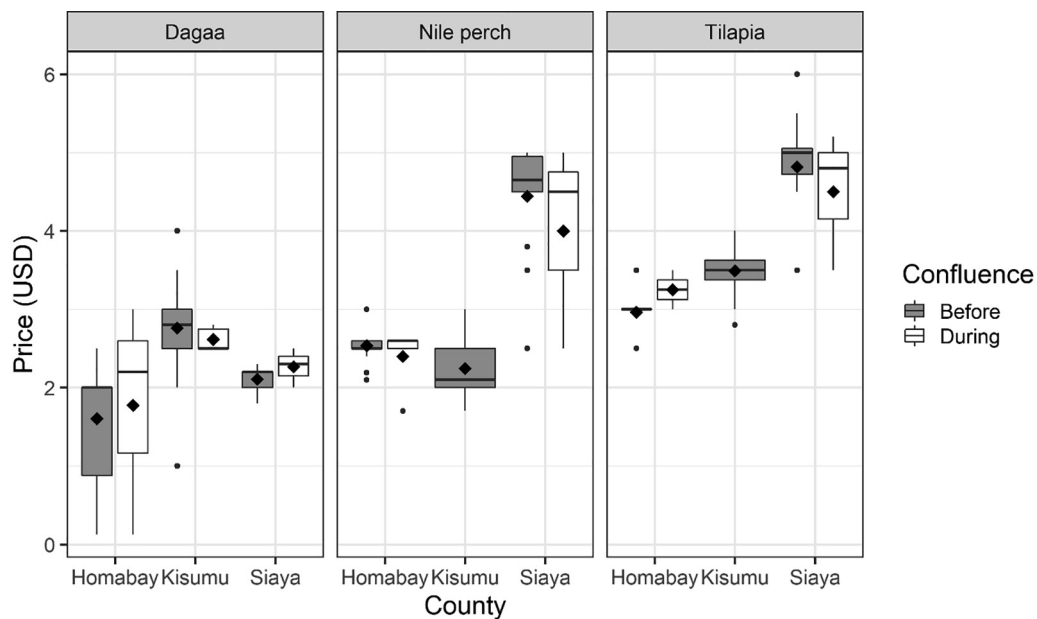

Fig. 5. Comparisons of prices (in USD) of major commercial fish species at selected major riparian counties of Lake Victoria, Kenya before and during Covid-19 and flooding based on EFMIS data.
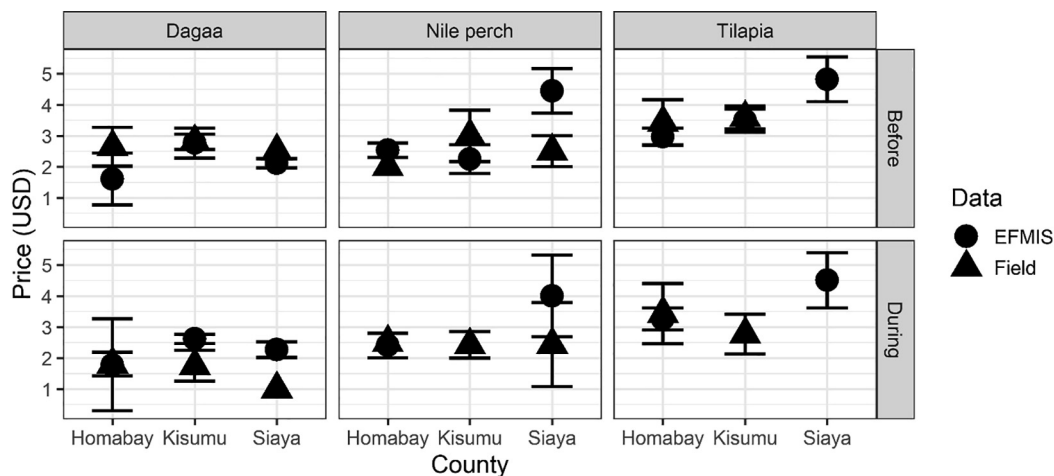

Fig. 6. Validation of socioeconomics field collected during this study with EFMIS data of the price of major commercial fishes (in USD) before and during Covid-19 and flooding in selected riparian counties of Lake Victoria, Kenya. The error bars show the range of fish prices data at each data type (EFMIS or Field) before and during Covid-19 pandemic and floods.
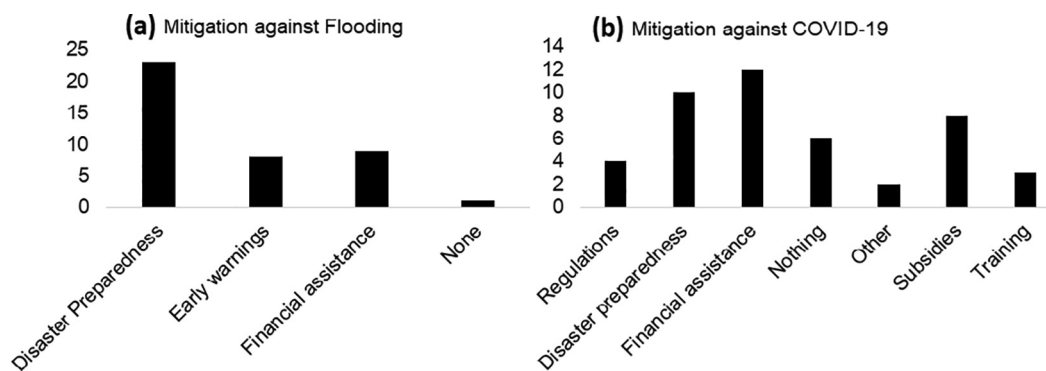
Fig. 7. Number of respondents proposing different mitigation measures for COVID-19 and floods in Kenyan major lakes.

Notably, there was no significant difference between the EFMIS data and the field data collected during this study (Fig. 6).

The respondents proposed various intervention measures to the COVID-19 pandemic and floods (Fig. 7). Key among these included disaster preparedness and financial assistance. Ishiwatari et al. (2020) proposed an integrated approach to disaster management, which starts with adequate preparedness. On the other hand, the unexpected and rapid onset of the COVID-19 situation could have called for the prioritization of financial assistance as its main intervention measure.

Conclusion and recommendations

This study was intended to demonstrate the short term consequences of calamities such as COVID-19 pandemic and flooding on vulnerable dependent communities such as those of inland capture fisheries to guide interventions towards sustaining livelihoods now and in the future. Although done for a short period, it provides a basis for further discussion and research on addressing impacts of calamities which are increasing in frequency on vulnerable resources and communities and how these should be addressed. The study showed that all the lakes examined registered substantial livelihood and material losses from the COVID-19 pandemic and floods. The COVID-19 pandemic containment regulations were cited to have impacted fishing and fishing trade due to curfew (66%) and lock-downs (28%) in major cities of Nairobi and Mombasa that act as major markets of fish. The fishing time, consumables such as boat fuel used during fishing activities, and the frequency of fishing trips were reduced due to the COVID-19 pandemic and floods. resulting into a cross-cutting decline in catch quantities and prices of fish. Nile perch as an export fishery experienced setbacks during the COVID-19 pandemic, amidst flooding due to restrictions, lockdowns and curfews. but also suffered from lowered internal and international trade and movements.

The prominent interventions proposed by the fish value chain actors included disaster preparedness and financial assistance. In order to withstand the inland fisheries shocks that are caused by calamities, this study recommends the development of an integrated fisheries management strategy for combating calamities in the Kenya inland lakes. There is also need for more detailed research on the impact of calamities to provide information and data to guide policy and management actions.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jglr.2020.09.007.

References

Africa Press Office, 2020. Coronavirus – Africa: COVID-19 could not have come at a worse time for vulnerable communities across West Africa. CNBC Africa, April 27, 2020. https://www.cnbcafrica.com/africapress-office/2020/04/27/coronavirus-africa-COVID-19-could-not-have-come-at-a-worse-time-for-vulnerablecommunities-across-west-africa/.

Agboola, O.P., Azizul, M.F., Rasidi, M.H., Said, I., 2018. The cultural sustainability of traditional market place in Africa: A new research agenda. J. Rural Stud. 62, 87–106.

Aloo, P.A., 2002. Effects of climate and human activities on the ecosystem of Lake Baringo. In: Odada, E.O., Olago, D.O. [Eds]. The East African Great Lakes: Limnology, Paleolimnology and Biodiversity. Advances in Global Research 12. Kluwer Academic Publishers. Dordrecht. pp 335-348.

Anadolu Agency News, 2020. Kenya confirms first Coronavirus case. https://www.aa.com.tr/en/africa/kenya-confirms-first-coronavirus-case/1764717.

Asteriou, D., Hall, S.G., 2011. ARIMA Models and the Box-Jenkins Methodology. Applied Econometrics (2nd ed.). Palgrave MacMillan. pp. 265–286. ISBN 978-0-230-27182-1.

Aura, M.C., Nyamweya, C.S., Owili, M., Gichuru, N., Kundu, R., Njiru, J.M., Ntiba, M.J., 2020. Checking the pulse of the major fisheries of Lake Victoria Kenya, for sustainable management. Fish Manag Ecol. 00:1–11. doi: 10.1111/fme.12414.

Aura, M.C., Musa, S., Yongo, E., Okechi, J., Njiru, J.M., Ogari, Z., Wanyama, R., Charo-Harrison, H., Mbugua, H., Kidera, S., Ombwa, V., Abwao, J., 2018. Integration of mapping and socio-economic status of cage culture: towards balancing lake-use and culture fisheries in Lake Victoria. Kenya. Aquaculture Res. 49 (1), 532–545.

Aura, M.C., Nyamweya, C.S., Njiru, J.M., Odoli, C., Musa, S., Ogari, Z., Abila, R., Okeyo, R., Oketch, R., 2019. Using fish landing sites and markets information towards quantification of the blue economy to enhance fisheries management. Fish. Manag. Ecol. 26, 141–152.

BBC News, 2020. Rising water levels in Kenya's Great Rift Valley threaten jobs and wildlife. https://www.bbc.com/news/av/world-africa-53776774.

Béné, C., Friend, R.M., 2011. Poverty in small-scale fisheries: old issue, new analysis. Prog. Development Stud. 11 (2), 119–144.

Béné, C., Lawton, R., Allison, E.H., 2010. 'Trade matters in the fight against poverty': narratives, perceptions, and (lack of) evidence in the case of fish trade in Africa. World Dev. 38, 933–954.

Bennett, N.J., Finkbeiner, E.M., Ban, N.C., Belhabib, D., Jupiter, S.D., Kittinger, J.N., Mangubhai, S., Scholtens, J., Gill, G., Christie, P., 2020. The COVID-19 pandemic,

small-scale fisheries and coastal fishing communities. Coastal Manage. https://doi.org/10.1080/08920753.2020.1766937.

CFFA, 2020. Coalition for Fair Fisheries Agreements - African artisanal fishermen call for measures to help them cope with the COVID-19 Epidemic. Coalition for Fair Fisheries Agreements. April 6, 2020. https://www.cffacape.org/news-blog/african-artisanal-fishermen-call-for-measures-to-help-them-call-cope-withthe-COVID-19-epidemic.

Dao, T., 2020. Coronavirus outbreak to hit Vietnam's Pangasius, shrimp exports in short-term. SeafoodSource. February 5, 2020. https://www.seafoodsource.com/news/supply-trade/coronavirus-outbreak-to-hit-vietnam-s-pangasius-shrimp-exports-in-short-term.

Dugan, P., Dey, M.M., Sugunan, V.V., 2006. Fisheries and water productivity in tropical river basins: enhancing food security and livelihoods by managing water for fish. Agricultural Water Management 80, 262-275.

FAO, 2020. Food and Agriculture Organization – How Is COVID-19 affecting the fisheries and aquaculture food systems. Rome: Food and Agriculture Organization of the United Nations. 10.4060/ca8637en.

Freduah, G.P., Fidelman, Smith, T.F., 2017. The impacts of environmental and socio-economic stressors on small-scale fisheries and livelihoods of fishers in Ghana. Appl. Geogr. 89 (December), 1–11. https://doi.org/10.1016/j.apgeog.2017.09.009.

Gangadhar, N., 2011. The role and relevance of ict use in fisheries sector in India: emerging policy implications. Int. J. Adv. Res. Manage. Technol. 1 (1), 1–14.

Gownaris, N.J., Pikitch, E.K., William, O.J., Michener, R., Kaufman, L., 2015. Predicting species' vulnerability in a massively perturbed system: the fishes of Lake Turkana, Kenya. PLoS ONE 10, e0127027.

Hamerlynck, O., Duvail, S., Vandepitte, L., Kindinda, K., Nyingi, D.W., Paul, J.-L., Yanda, P.Z., Mwakalinga, A.B., Mgaya, Y.D., Snoeks, J., 2011. To connect or not to connect? Floods, fisheries and livelihoods in the Lower Rufiji floodplain lakes, Tanzania. Hydrol. Sci. J. 56 (8), 1436–1451.

Harper, D.M., 1992. The ecological relationships of aquatic plants at Lake Naivasha, Kenya. Hydrobiologia 232, 65–71.

Harper, D., Mavuti, K., 2004. Lake Naivasha: ecohydrology to guide the management of a tropical protected area. Ecohydrol. Hydrobiol. 4, 287–305.

Hickley, P., Muchiri, M., Britton, R., Boar, R., 2008. Economic gain versus ecological damage from the introduction of non-native freshwater fish: Case studies from Kenya. Open Fish Sci. J. 1 (1), 36–46.

Hulme, M., Doherty, R., Ngara, T., New, M., Lister, D., 2010. Africa climate change: 1900–2010. Clim. Res. 17, 145–168.

Hyndman, R.J., Khandakar, Y., 2008. Automatic time series forecasting: the forecast package for R. J. Stat. Softw. 27 (1), 1–22.

Immanuel, S., 2020. Fisheries begging to return to work. The Namibian, April 4, 2020. https://www.namibian.com.na/index.php?page=read&id=90194.

IPCC, 2013. Climate Change 2013: The Physical science basis. Working Group I contribution to the fifth assessment report of IPCC. 36pp.

Ishiwatari, M., Koike, T., Hiroki, K., Toda, T., Katsube, T., 2020. Managing disasters amid COVID-19 pandemic: approaches of response to flood disasters. Progress in Disaster Science 6,. https://doi.org/10.1016/j.pdisas.2020.100096 100096.

JHU, 2020. Johns Hopkins Coronavirus Resource Center COVID-19 Map. John Hopkins Coronavirus Resource Center. https://coronavirus.jhu.edu/map.html.

Källqvist, T., Lien, L., Liti, D., 1987. Lake Turkana – Limnological Study 1985-1988. Norwegian Institute for Water Research (NIVA), Kenya Marine and Fisheries Institute. 99 pp.

Kimani, E.N., Aura, M.C., Okemwa, G., 2018. (eds). The Status of Kenya Fisheries: Towards the sustainable use of renewable aquatic resources for economic development. Kenya Marine and Fisheries Research Institute (KMFRI), Fisheries Book. Kenya. 177 pp.

Kitaka, N., Harper, D.M., Mavuti, K.M., 2002. Phosphorus inputs to Lake Naivasha, Kenya, from its catchment and the trophic state of the lake. Hydrobiologia 488 (1–3), 73–80.

Kohfeld, K.E., Harrison, S.P., 2000. How well can we simulate past climates? Evaluating the models using global palaeoenvironmental datasets. Quat. Sci. Rev. 19 (1–5), 321–346.

Kolding, J., van Zwieten, P.A.M., 2012. Relative lake level fluctuations and their influence on productivity and resilience in tropical lakes and reservoirs. Fisheries Research 115-116, 99.

Kolding, J., van Zwieten, P., Marttin, F., Poulain, F., 2016. Fisheries in the drylands of Sub-Saharan Africa "Fish come with the Rains". FAO Fisheries and Aquaculture Circular No. 1118.

Welsh, T., 2020. WFP Chief Warns of 'hunger Pandemic' as COVID-19 threatens food security. Devex (blog). April 22, 2020. https://www.devex.com/news/sponsored/wfp-chief-warns-of-hunger-pandemic-asCOVID-19-threatens-food-security-97058.

Lévêque, C., 1995. Role and consequences of fish diversity in functioning of African freshwater ecosystems: a review. Aquat. Living Resour. 8, 59–78.

Long'ora, A.E., Abuom, P.O., Owiti, D.O., Malala, J.O., 2015. Influence of artisanal fishing gears on physico-chemical parameters of Ferguson's Gulf in Lake Turkana, Kenya. Sch. Acad. J. Biosci. 3(12), 1005-1013.

LVFO, 2015. Lake Victoria Fisheries Organization Jinja, Uganda: Lake Victoria (Kenya) Biennial Fisheries Frame Survey 2014 National Report. Ministry of Agriculture, Livestock and Fisheries, Nairobi, Kenya. 36pp.

Lwenya, C.A., Lwenya, K.R., Abila, R., Omwega, R., 2006. Gender participation in fisheries management of Lake Victoria, Kenya. Accessed (online) from http://oceans.org/bitstream/1834/3570/1/WLCK-266-272 on 9th June 2020.

Marshall, B.E., Mkumbo, O.C., 2011. The fisheries of Lake Victoria: past present and future. Nature & Faune 26, 8–13.

Mulatu, D.W., van Oel, P.R., Odongo, V., van der Veen, A., 2018. Fishing community preferences and willingness to pay for alternative developments of ecosystem-based fisheries management (EBFM) for Lake Naivasha, Kenya. Lakes & Reservoirs: Science, Policy and Management for Sustainable Use. https://doi.org/10.1111/lre.12225.

Musinguzi, L., Lugya, J., Rwezawula, P., Kamya, A., Nuwahereza, C., Halafo, J., Kamondo, S., Njaya, F., Aura, M.C., Shoko, A.P., Osinde, R., Natugonza, N., Ogutu-Ohwayo, R., 2019. The extent of cage aquaculture, adherence to best practices and reflections for sustainable aquaculture on African inland waters. J. Great Lakes Res. 45, 1340–1347.

MoH News, 2020. Ministry of Health, Kenya. Health Ministry announce 127 new cases of COVID-19 Nairobi, Tuesday June 9, 2020. https://www.health.go.ke/health-ministry-announce-127-new-cases-of-covid-19-nairobi-tuesday-june-9-2020/.

Njiru, J.M., Aura, M.C., Okechi, J.K., 2019. Cage fish culture in Lake Victoria: a boon or a disaster in waiting?. Fish Manag. Ecol. 26, 426–434.

Njiru, M., Ojuok, J.E., Okeyo-Owuor, J.B., Muchiri, M., Ntiba, M.J., Cowx, I.G., 2006. Some biological aspects and life history strategies of Nile tilapia Oreochromis niloticus (L.) in Lake Victoria, Kenya. African Journal of Ecology 44(1), 30–37.

Njiru, M., Sitoki, L., Nyamweya, C.S., Jembe, T., Aura, C., Waithaka, E., Masese, F., 2012. Habitat degradation and changes in Lake Victoria fisheries. In In: Adoyo, W. A. & Wangai, C. I. Environmental Degradation: Causes, Issues and Management. New York: NOVA Science Publishers, Inc., pp. 1–34.

Nyamweya, C.S., Natugonza, V., Taabu-munyaho, A., Aura, M.C., Njiru, M., Ongore, C., Mangeni-, R., Kashindye, B.B., Odoli, C.O., Kayanda, R., 2020. A century of change: induced revolution of Lake Victoria fisheries and ecology. Fish. Res. 230,. https://doi.org/10.1016/j.fishres.2020.105564 105564.

Obando, J., Onywere, S., Shisanya, C., Ndubi, A., Masiga, D., Irura, Z., Mariita, N., Maragia, H., 2016. Impact of Short-Term Flooding on Livelihoods in the Kenya Rift Valley Lakes in "Geomorphology and Society (pp.193-215)". 10.1007/978-4-431-56000-5_12.

Ongore, C., Aura, M.C., Ogari, Z., Njiru, J.M., Nyamweya, C., 2018. Spatial-temporal dynamics of water hyacinth, Eichhornia crassipes(Mart.), other macrophytes and their impact onfisheries in Lake Victoria, Kenya. J. Great Lakes Res. 44 (6), 1273–1280.

R Core Team (2020). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

Rajeev, M., Nagendran, P., 2020. Understanding regional variation in fish prices: evidence from a developing economy. J. Agribusiness in Developing and Emerging Economies Vol. ahead-of-print No. ahead-of-print. doi: 10.1108/JADEE-09-2019-0158.

Taunton, E., Cropp, A., 2020. Coronavirus: Crayfish Not Exported to China to Be Freed. Stuff, February 5, 2020. https://www.stuff.co.nz/business/119285477/coronavirus-crayfish-not-exported-to-chinato-be-freed.

Tester, H., 2020. Coronavirus impact: Florida fishing industry smacked hard by pandemic. CBS Miami, April 22, 2020. https://miami.cbslocal.com/2020/04/22/florida-fishing-industry-coronavirus/.

United Nations (UN News), 2020. UN working to avert dual crises as COVID-19 hits hunger hotspots. United Nations, 2020. https://www.un.org/en/un-coronavirus-communications-team/un-working-avertdual-crises-COVID-19-hits-hunger-hotspots.

Welcomme, R.L., 1970. Studies on the effect on abnormal high water levels on the ecology in certain shallow regions on Lake Victoria. J. Zool. 160, 405–436.

Welcomme, R., 2008. World prospects for floodplain fisheries. Ecohydrol. Hydrobiol. 8, 169–182.

Woodhead, A.J., Abernethy, K.E., Szaboova, L., Turner, R.A., 2018. Health in fishing communities: a global perspective. Fish and Fisheries. https://doi.org/10.1111/faf.12295.