ajfand AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT

SCHOLARLY, PEER REVIEWED

Volume 24 No. 2
February 2024

PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

*Afr. J. Food Agric. Nutr. Dev*. 2024; 24(2): 25391-25408 https://doi.org/10.18697/ajfand.127.23355

| Date | Submitted | Accepted | Published |
|---|---|---|---|
| | 5th April 2023 | 28th April 2023 | 29th February 2024 |


# NON-NATIVE FISH SPECIES AS AN IMPORTANT PART OF ZAMBIA'S FOOD SYSTEM: A CASE STUDY OF THE LAKE KARIBA FISHERY

**Pojana M[1,2]* and WL Jere[1]**

**Mebbah Pojana**

*Corresponding author email: mebbahpojana@gmail.com

[1]Africa Centre of Excellence in Aquaculture and Fisheries, Department of Aquaculture and Fisheries Science, Lilongwe University of Agriculture and Natural Resources, P.O. Box 219, Lilongwe, Malawi

[2]Zambia College of Agriculture, P.O. Box 450143, Mpika, Zambia

## ABSTRACT

Fish have an important role in food systems of Zambia and are a cheaper source of animal protein, vitamins and minerals. Presently, fish catches are dwindling and many children and women in rural Zambia are malnourished because their diet consists mainly of maize, vegetables and legumes. The main component of the diet is nsima, a form of thick porridge prepared from maize flour, which provides energy as carbohydrates. This study was done to assess the impact of a non-native fish species (*Oreochromis niloticus,* Nile tilapia) which has both positive and negative impacts on Zambia's food system, with particular reference to the Lake Kariba fishery. The study was based on a networked systems framework, achieved through the administration of questionnaires, interviewing 377 randomly selected respondents from the three areas of the lake (I, II and IV) and 156 respondents from 7 selected open fish markets. Focus group discussions (FGD) were done with women, men and youth, who were key informants. Analysis of results using chi-square analysis, which cross-tabulated variables were used to obtain the results. Non-native fish were introduced in the early 1980s for cage culture production in Lake Kariba but some fish accidentally escaped. This has changed the composition and abundance of fish species in the lake. Despite the negative ecological impact on native biodiversity, results showed that more fish are available to households, improving nutrition and disposable income from fish sales. The disposable income is used to purchase other foods, thereby reducing malnutrition among rural households. Thus, the introduction of appropriate non-native species might benefit households and the nation as a whole.

**Key words:** Malnutrition, non-native fish species, Lake Kariba, Zambia, tilapia, *Oreochromis niloticus*

ajfand AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
SCHOLARLY, PEER REVIEWED
Volume 24 No. 2
February 2024
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

## INTRODUCTION

Food insecurity and household poverty are high in rural Zambia, with 42% living in extreme poverty [1]. Over 54% of people are hungry and do not eat enough [2]. According to the Zambia Statistics Agency of the Ministry of Health [3], malnutrition is high, especially 35% of children <5 years of age are stunted (short for their age) and 4% are wasting, 5% are underweight and 5% are overweight. Persistent iron deficiency anemia in children has been attributed to a diet dominated by cereals containing phytic acid, which interferes with iron absorption [2].

Fish are an important part of Zambia's food system and are an affordable source of nutrients (iron, vitamin A, calcium and zinc), making them helpful in addressing many nutritional problems, especially among women and children [4]. The fish reach consumers through multiple routes [5]. This system includes all aspects including production activities, procurement, transportation, storage, trading (including processing and packaging), and consumption activities associated with capture fisheries and aquaculture [6]. Fish consumption is determined by many factors including fish price, fish form, availability, taste and culture [6]. Fish may reduce hunger in Zambia and provide essential nutrients to malnourished women and children [4].

In Zambia, there have been incidental fish introductions because the weak legislation allowed non-natives species to be brought into the country without permits and these were later found in natural waters. According to FAO [7] and Ellender *et al.* [8], Nile tilapia (*Oreochromis niloticus*) were acquired by fish farms along the Kafue River in the 1980s, but escaped into the river system, and have successfully colonized the river. In 1986, *O. niloticus* were taken to Zimbabwe for fish farming in cages on Lake Kariba, and over the years several fish species were introduced into the lake, eventually populating the entire lake [9, 10, 11]. For example, *Limnothrissa miodon* also known as Kapenta in the local language, was deliberately introduced from Lake Tanganyika to Lake Kariba between 1967 and 1968 [11] and became one of the most important commercial species in the Lake Kariba fishery. This species has also been deliberately introduced to other water bodies in Zambia, such as Lake Itezhi Tezhi [7].

The freshwater crayfish (*Cherax quadricarinatus*) was also introduced for aquaculture several times in Zambia between 1979 and 2000 and again have populated both the Kafue River and Lake Kariba [12]. The *C. quadricarinatus* now established in Lake Kariba were supposedly imported from Swaziland, placed in aquaculture cages in the Siavonga district along the lakeshore, and escaped into the lake in 2002 [12].

ajfand
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
SCHOLARLY, PEER REVIEWED
Volume 24 No. 2
February 2024
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

The abundance of these invasive species are increasing, suggesting that they may influence the abundance and species composition of native species in the Lake Kariba fishery, as evidenced by changes in daily catches [13]. Non-native fish species can also affect ecosystem services provided by the Lake Kariba fisheries, such as providing household income and nutrition. According to Musumali *et al.* [14] in Zambia and most of sub-Saharan Africa, fish constitutes a high proportion of animal protein in household diets, i.e., up to 40%. According to Aylward [15], services include water for fish production and consumption (domestic, agricultural, industrial, and ecoservices).

The introduction of non-native species influences the types of fish species consumers seek based on characteristics such as taste, availability, market price and perception. This impacts the entire food fish system, which is essential for household nutrition. This paper studies the important role of non-native fish in Zambia's food system, particularly in relation to the Lake Kariba fishery.

## MATERIALS AND METHODS

The study was based on the assumption of an interlinked system that can provide health, environmental, economic and innovation benefits [16]. The interlinked system embraces the entire range of actors and their interlinked value-adding activities. It takes into account all activities involved with the production, aggregation, processing, distribution, consumption and disposal (loss or waste) of food products originating from agriculture (including livestock), forestry, fisheries and food industries according to Braun [16].

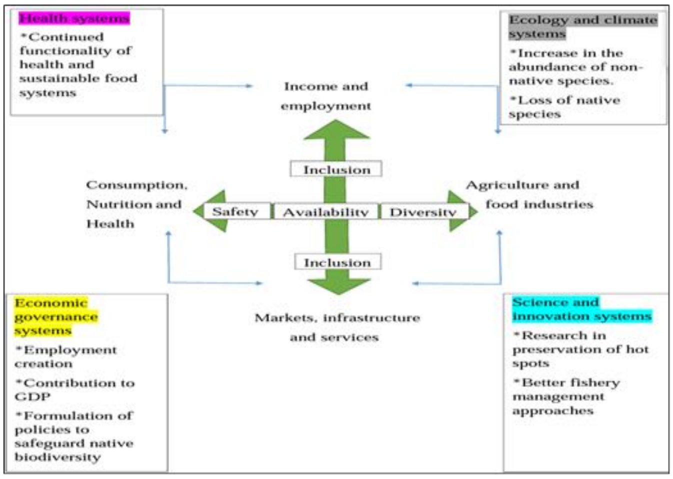


**Figure 1: Adapted interlinked systems that describe the food system in terms of systems with positive benefits such as health, environmental services, economics and innovation**

ajfand AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
SCHOLARLY, PEER REVIEWED
Volume 24 No. 2
February 2024
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

**Description of the Study Sites**
This survey was conducted in three areas: Stratas I, II and IV of Lake Kariba based on the geographical and ecological characteristics and limnologic structure of the lake [8, 11, 17]. Data were collected in the Sinazongwe, Siansowa and Siavonga areas of Zambia. These were picked because they had well-defined fishing villages and easy access. The fisheries research station is located in Sinazongwe adjacent to the shores of Lake Kariba, which has a population of ~100,000 [18].

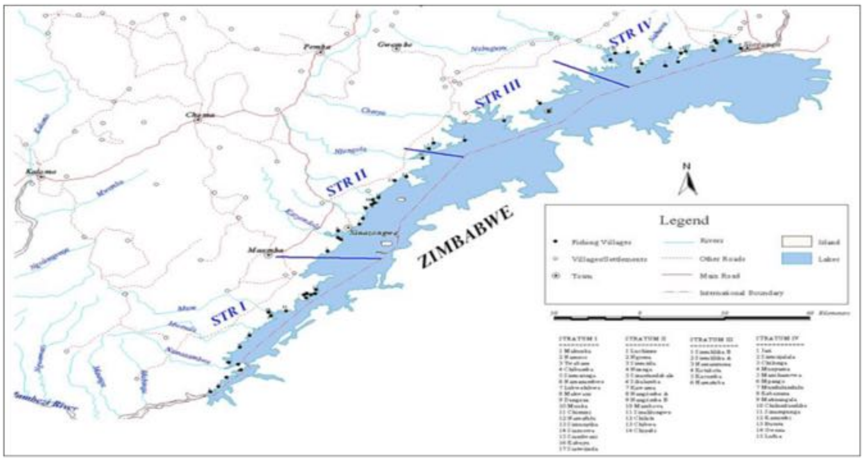


**Figure 2: Map of Lake Kariba showing the four strata. Source: Lake Kariba Fisheries Research Unit, 2013**

**Sample Size**
A total of 377 respondents determined using Cochran's formula were interviewed. The Cochran formula was used because the size of the population in the study site was not known [19]. Respondents were selected using a non-probability sampling technique. Eight village headmen and six Department of Fisheries (DOF) workers were interviewed as the main informants. Three focus group discussions (FGD) were conducted in each strata. Each FGD involved fishers (females, males and youths) and traders. Due to the COVID-19 outbreak during data collection, the FGD was limited to between 6 to 8 respondents and one-to-one discussions (individual data) were done [20] to avoid larger groups. An additional 156 consumers were interviewed about their fish preferences at open fish markets in 7 districts in 6 provinces across the country. The districts were Kasama in the Northern Province, Mpika in Muchinga Province, Petauke in the Eastern Province, Ndola in the Copperbelt Province, Kafue and Luangwa in Lusaka Province and Sinazongwe in the Southern Province.

ajfand
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
SCHOLARLY, PEER REVIEWED
Volume 24 No. 2
February 2024
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

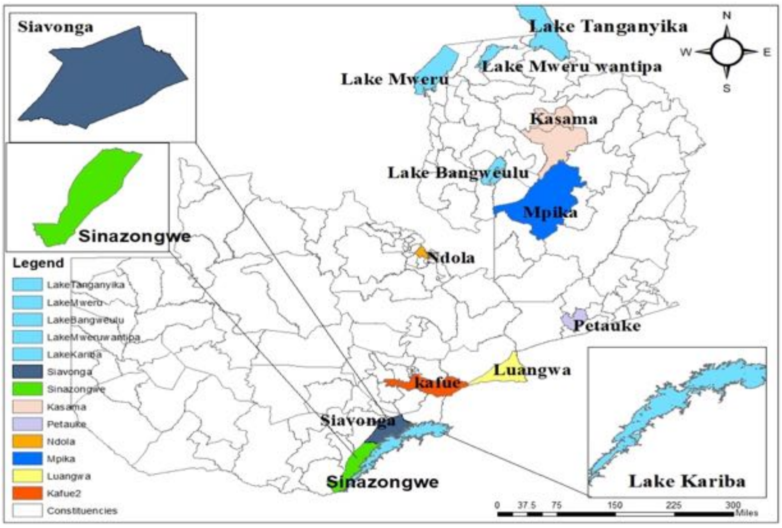


**Figure 3 : Map of Zambia showing the study site ( Lake Kariba fishery) and the 7 fish consumption study sites**

## Data Collection Tools and Surveys

The survey used a semi-structured questionnaire. This was done to ensure that detailed information was collected from the respondents. Data collected include demographics such as gender, years of fishing, current factors encouraging the use of non-native species, and impacts of change on the abundance and distribution of different non-native and native fish species on the lake, species preferences based on customer demand, pricing of different fish species at sales points depending on whether its fresh, dried or smoked, and the impact that the non-native fish species have on the environment and on households.

## FGD

Focus group discussions (FGD) were used to validate the data. They were aimed at obtaining detailed information on the contribution that the non-native fish species have on food systems. In total, 12 focus group discussions were conducted, four in each of the three study locations. The first group were women only, the second was youth only, the third was men only, and the fouth was a combination of men, women and the youth (15 to 21 years) who were either fishers, traders or consumers. Thirteen enumerators were trained on how to administer the questionnaire and how to facilitate group meetings to ensure uniformity in asking questions to the respondents, thereby reducing bias.The process of data collection, moderation and interpretation was done based on the framework analysis, starting in the field [21]. Framework analysis is a qualitative approach that involves the organisation and analysis of data using a predefined analytical framework.

**Key Informants**

Key informants included village headmen who have stayed around Lake Kariba for more than ten years and have been involved in fishing for a long time and have a lot of information about the fishery. Fisheries experts were also interviewed. These were members of the staff working at the Fisheries Research Institute located in Sinazongwe. Other community members who worked in the area were also interviewed. Key informants were interviewed using a check list that was a set of specific questions extracted from the questionnaire to validate the information gathered through the surveys and FGD.

**Data Analysis**

Data collected through questionnaires were coded and entered into IBM SPSS version 21 (USA), to provide descriptive results and percentages for each response. Coding is a method in which responses recorded in the questionare from a survey are converted into codes that allows computer-based analysis to be undertaken. Analysis of results using chi-square analysis, which cross-tabulates variables in SPSS and then Microsoft Excel version 2016 (USA ) were used to generate the figures. Responses from the FGD and key informants were analyzed using summative content analysis [22]. To validate the data from the questionnaire, an FGD analysis matrix was created in Microsoft Excel with different themes or headings. Responses from different groups were entered against the different themes. Similar responses or words were counted, summed up and their frequencies calculated. The frequencies of the responses or words were compared with responses from the questionnaire under the same theme to determine the validity of the responses from the questionnaire. To meet the objectives of the study, different themes were used to validate the data such as the demand for non-native species, consumption of fish based on preferences, fish introductions and its effects, the type of changes in fish abundance that have taken place in the lake and what type of fish species were dominant in the lake.

## RESULTS AND DISCUSSION

As the adapted food system matrix in Fig.1 shows, the introduction of non-native fish species has a significant impact on human life. According to Braun [16], the concept has four main components: ecology and climate systems, health systems, economic and governance systems, and science and innovation systems

**Ecology and Climate Systems**

Results showed significant association ($p = 0.0001$) between species occurring in the Lake Kariba fishery and the respondents' perception of species dominance (Table 1). Most of the respondents believed that daily catches are dominated by the non-native species (especially *O. niloticus*) which was indicated by 58% of all



https://doi.org/10.18697/ajfand.127.23355

ajfand AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
SCHOLARLY, PEER REVIEWED
Volume 24 No. 2
February 2024
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

daily catches.There are five distinct stages of species invasion that have been described that lead to an increased abundance of introduced or non-native species [23]. These come about as a result non-native species out competing the native species after introduction. There are different stages of invasion that lead to an increase in the abundance of an introduced species. This increase in the abundance of introduced non-native species has led to a decrease in the abundance of native species, leading to biodiversity loss as stated by Ballew *et al.* [24]. Declining numbers of native species are caused by the depletion of resources such as food and space [25], which reduces the growth of native species. According to Bbole *et al.* [26] non-native species also interbreed with closely related species, reducing the abundance of such native species. Fish introductions/translocations have occurred in Lake Kariba, affecting the abundance of native species [7], and among them, *O. niloticus* has had the greatest ecological impact [27]. The increase in abundance of non-native species has been confirmed in a recent report based on catch assessment figures that shows an increase in *O. niloticus* weight (32%) compared to a total *Oreochromis* species increase weight of 3% [13]. The study also suggested that stakeholders involved in the entire fish chain believe that the introduction of non-indigenous fish such as *O. niloticus* and *L. miodon* could have adverse effects on ecosystems due to the observed increase in fish abundance during catching. According to the International Union for the Conservation of Nature [28], population increases of non-native species could have led to population declines or disappearances of congenerics of *O. andersonii* and *O. macrochir* which has been classified as vulnerable (VU) while *O. mortimeri* has been classified as endangered (CR), respectively.

**Science and Innovation Systems**

The non-native fish species of Lake Kariba now dominate the native species. Data from capture rates indicate that non-native species are increasing in abundance [13]. According to Kiruba-Sankar [23], some degree of control should occur once a species invasion reaches a dominant stage. Given the high demand for non-native species from fishers, traders and consumers, control mechanisms will adversely affect all stakeholders who depend on these species.

Efforts should be directed towards protecting such alien species by exploiting them for the benefit of many households [23]. Research should now probably focus on maintaining a balance between non-native and native species by maintaining hotspots for native species. There is also a need to focus on finding new approaches, for example, for fisheries management.

**Economic and Governance Systems**

Although negative ecological impacts have long been associated with non-native fish species [23], there are also positive economic impacts accrued to the

ajfand AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
SCHOLARLY, PEER REVIEWED
Volume 24 No. 2
February 2024
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

stakeholders across the fish value chain. In this study, there was a significant association ($p < 0.0001$) between changes occurring in the Lake Kariba fishery and the respondents' perception (Table 2). Almost half of the respondents believed that fish changes in abundance (42%) and 13% indicated that water levels had increased. There was also a significant association ($p = 0.0003$) between respondents' perceptions of non-native species in Lake Kariba and their perceptions of the impact of non-native species on their livelihoods (Table 3) indicating that non-native species such as *O. niloticus* have had perceived positive impacts on the livelihoods of fishermen and traders. This increase in fish populations usually resulted in positive changes in people's lives through local job creation that occurs on both a temporary and permanent basis [29]. Jobs created include processing activities such as selling and repairing canoes, supplying nets, and drying fish. The results of the study recognize these significant positive effects associated with introduced non-native fish species through increased income as was observed by Njiru *et al.* [30]. There was also increased purchasing power that enables households to buy more food and diversify their diets, helping to reduce malnutrition as also stated by Kawarazuka and Béné [31]. Fishers have contributed to Zambia's GDP by contributing tax revenues throughout the value chain. Increased fish stocks will also continue to increase Zambia's export earnings. Between 2001 and 2019 trade in fish and fish products increased. Zambia's fresh, dried, salted, smoked and brined fish exports were estimated at USD 3 million [32]. This contributes significantly to the country's GDP that translates into improved provisions of socio-economic amenities.

**Health Systems**
Results on fish consumption were not significant ($p = 0.6841$) from the 156 fish consumers interviewed from different open fish markets from seven districts in six provinces of Zambia, (Table 4). Most fish consumers (54%) indicated their preference for non-native species compared to native species (44%) which means that both non-native and native species are preferred. There was also no significant association ($p = 0.9619$) between demand for alien species and study area (Table 5). According to Zambia's 2022 Population and Housing Census [18], Zambia has a population of ~19,600,000 consisting of ~2,330,000 households of which 11.8 million live in rural areas [32]. Zambia's population growth is 3.4%/yr [33]. With such population growth, fish demand is expected to continue to increase [34]. Most of these rural households are food insecure, with poverty rates reaching 42%. Most people do not eat enough and 54% of people suffer from hunger when they do not have enough food [2]. Malnutrition is high among the population especially children [3] with persistent iron deficiency anaemia in children being attributed to the decline in the consumption of iron-rich foods, including fish. Nsima, a local main dish component of maize milled into a desired degree of

fineness and cooked into a porridge, is a common dish served with a variety of vegetable leaves, pulses, meat and fish [33]. Although the results of the study were non significant, regardless of class, non-native fish species were in high demand. Therefore, as a result of increased abundance from non-native since introduction and native species, fish as part of the food system could have an important role in ensuring the continued functionality of healthy and sustainable food systems by making available healthy and sustainable diets that provide a good source of high-quality proteins and essential fatty acids [35]. With the increased demand for introduced species across all areas of the Lake Kariba fishery and Zambia as a whole by traders resulting from consumer preferences, fish could help in the reduction of the widespread malnutrition that is found among children and other vulnerable groups in most rural and peri-urban populations. Although there is a decline in the abundance of native fish species, this study has shown that over the years, there are perceived benefits associated with the introduction of alien species which has had a positive impact on livelihoods and may help alleviate widespread malnutrition in rural Zambia. Individuals have been shown to have reduced incidence of anemia and common infections [36]. Fish are an important food source that contributes significantly to the well-being of many households [2]. However, to enable households to benefit from the increasing abundance of changing resources in rural areas affecting fish consumption are availability, income levels and prices, all of which must be considered [14].

## CONCLUSION, AND RECOMMENDATIONS FOR DEVELOPMENT

Non-native fish are an important component of the food supply in Zambia. Although non-native fish species have a negative ecological impact on ecosystems, they also affect the people involved throughout the fish value chain, especially communities, fishers, processors, traders, consumers and many governments. Non-native species provide economic, social and nutritional benefits to malnourished and vulnerable groups. Non-native species contribute to more fish being available to most households which improves nutrition and disposable income from fish sales along the value chain. The income generated by households is used to purchase other foods to improve the diversity of the diets thereby reducing malnutrition among rural households. Thus, the introduction of appropriate non-native species could benefit many households and the nation as a whole.

## ACKNOWLEDGEMENTS

The author would like to thank the German Government through the Germany Academic Exchange Service (DAAD) for funding the entire study programme and Lilongwe University of Agriculture and Natural Resources based in Lilongwe, Malawi through the contributions of members of staff for my (MP) entire academic programme.

**Conflict of interest**

There are no conflicts of interest.

**Author Contributions**

***Mebbah Pojana:*** Conceptualization (lead); Data curation (lead); Formal analysis (lead); Methodology (lead); Writing-review & editing (equal).
***Wilson Lazaro Jere:*** Formal analysis (supporting); Methodology (equal); Supervision (equal); Writing-review & editing (equal).

**Data Availability Statement**

The data, including questionnaires that have been used in this study are available, and the Dryad data repository will be used to archive the data once the paper is accepted.

**Table 1: Perception of species dominance in daily catches of fish species in areas I, II and IV of Lake Kariba**

| | Respondents | | | |
|---|---|---|---|---|
| **Species perceived to be dominant** | **Fishers (n, %)** | **Traders (n, %)** | **Total (n, %)** | **Chi-square test** |
| *C. rendalli* | 52 (13.5) | 4 (1.1) | 56 (14.9) | |
| *O. mortimeri* | 48 (12.7) | 2 (0.5) | 50 (13.3) | |
| *M. longirostris* | 9 (2.4) | 5 (1.3) | 14 (3.7) | |
| *H. vittatus* | 9 (2.4) | 3 (0.8) | 12 (3.2) | $\chi^2 = 30.895$, p = < 0.001 |
| *O. niloticus* | 200 (53.1) | 17 (4.5) | 217 (57.6) | |
| *C. quadricarinatus* | 4 (1.1) | 0 (0.0) | 4 (1.1) | |
| None | 16 (4.2) | 8 (2.1) | 24 (6.4) | |
| Total | 338 (89.7) | 39 (10.3) | 337 (100.0) | |

**Table 2: Perception of changes in the Lake Kariba fishery by fishers and traders (n, %)**

| | **Perception of changes** | | |
|---|---|---|---|
| **Change in the fishery** | **Good** | **Average** | **Bad** |
| Increase in fish abundance | 13 (41.9) | 16 (51.6) | 2 (6.4) |
| Decrease in fish abundance | 22 (13.2) | 102 (61.1) | 43 (25.7) |
| Increase in water level | 20 (13.3) | 109 (72.7) | 21 (14.0) |
| Decrease in water level | 0 (0.0) | 2 (66.7) | 1 (33.3) |
| No changes | 0 (0.0) | 4 (40.0) | 6 (60.0) |
| Total | 55 | 233 | 73 |
| | $\chi^2 = 37.272$, df = 8, p < 0.0001 | | |

**Table 3: Respondent's awareness of the introduced Oreochromis niloticus and its effects on fishers' and traders' livelihoods (n, %)**

| | Effect on livelihoods | | |
|---|---|---|---|
| **Respondent's awareness** | **Positive** | **Negative** | **No response** |
| Yes | 163 (75.5) | 23 (45.1) | 70 (73.7) |
| No | 14 (6.5) | 4 (7.8) | 4 (4.2) |
| No response | 39 (18.1) | 24 (47.1) | 21 (22.1) |
| Totals | 216 | 51 | 95 |
| | $\chi^2 = 21.428$, df = 4, $p = 0.003$ | | |

**Table 4: Fish species consumption according to preferences**

| | Gender of respondent | | |
|---|---|---|---|
| **Fish species** | **Female (n, %)** | **Male (n, %)** | **Total** |
| Native | 41 (41.8) | 27 (46.6) | 68 (43.6) |
| Nonnative | 57 (58.2) | 31 (53.4) | 88 (56.4) |
| Total | 98 (100) | 58 (100) | 156 (100) |
| | $\chi^2 = 0.166$, $p < 0.684$ | | |

**Table 5: The demand for non-native species by traders in area I, II and IV of Lake Kariba**

| | Demand for non-native species | | |
|---|---|---|---|
| | **High** | **Low** | **No response** |
| Area I | 67 (28.0) | 6 (10.7) | 17 (25.4) |
| Area II | 160 (66.9) | 45 (80.4) | 47 (70.1) |
| IV | 12 (5.0) | 5 (8.9) | 3 (4.5) |
| Total | 239 | 56 | 62 |
| | $\chi^2 = 8.075$, df = 4, p = 0.089 | | |

## REFERENCES

1. **Zangar J** Reducing Poverty, Improving Food Security for Farmers in Zambia. United Nations Development Program - Strengthening Climate Resilience of Agricultural in Agro Ecological Regions I and II Project in Zambia. 2019.

2. **Kobayashi E, Negi B and M Nakazawa** The Association Between Food Groups and Childhood Anemia in Zambia, Based on the Analysis of Zambia Demographic and Health Survey 2018. *Journal of Public Health in Africa,* 2022; **13:**1.

3. **Zambia Statistics Agency, Ministry of Health (MOH) Zambia, and International Classification of Functioning, Disability and Health (ICF).** Zambia Demographic and Health Survey 2018. Lusaka, Zambia, and Rockville, MD, USA. Zambia Statistics Agency, Ministry of Health, and ICF, 2019.

4. **Nölle N, Genschick S, Schwadorf K, Hrenn H, Brandner S and KH Biesalski** Fish as a Source of (Micro)nutrients to Combat Hidden Hunger in Zambia. **Food Security,** 2020; **12:** 1385–1406.

5. **Phillips M, Marwaha N, Beveridge MCM, Benzie J, Cohen PJ, Delamare-Deboutteville J, Dubois M, McCartney M, McDougall C, Mohammed E, Mohan CV, Preston N, Rossignoli C, Sellamuttu SS, Simmance F, Tilley A, Verdegem M and R Yossa** CGIAR Research Program on Fish Agri-Food Systems: A synthesis. Penang, Malaysia: CGIAR Research Program on Fish Agri-Food Systems. Program Brief: FISH-2021-23 as a Source of (micro)nutrients to Combat Hidden Hunger in Zambia. *Food Security,* 2021; **12:** 1385–1406.

6. **Tezzo X, Bush RS, Oosterveer P and B Belton** Food System Perspective on Fisheries and Aquaculture Development in Asia. *Agriculture and Human Values,* 2021; **38:** 73–90.

7. **Food and Agriculture Organisation.** The Aquatic Animal Species Introduced or Translocated in Zambia. The Food and Agriculture Organisation of the United Nations, Rome, Italy. 1992.

8. **Ellender RB, Woodford JD, Weyl FLO and GI Cowxs** Managing Conflicts Arising from Fisheries Enhancements based on Non-Native Fishes in Southern Africa. *Journal of Fish Biology,* 2014; **85:** 6. https://doi.org/10.1111/jfb.12512

9. **Zengeya TA and BE Marshall** The Inshore Fish Community of Lake Kariba Half a Century after its Creation: What Happened to the Upper Zambezi Species Invasion? *African Journal of Aquatic Science,* 2008; **33(1):** 99–102.

10. **Maulu S and G Musuka** Assessing the Abundance and Distribution of Tilapia Species in Lake Kariba. *International Journal of Fisheries and Aquaculture Sciences,* 2018; **8(1):** 1-11.

11. **Hasimuna OJ, Maulu S, Monde C and M Mweemba** Cage Aquaculture Production in Zambia: Assessment of Opportunities and Challenges on Lake Kariba, Siavonga District. T*he Egyptian Journal of Aquatic Research,* 2019; **45(3):** 281-285. https://doi.org/10.1016/j.ejar.2019.06.007

12. **Takudzwa CM, South J, Wood EL, Unes LA and FLO Weyl** A Review of Freshwater Crayfish Introductions in Africa. Reviews in *Fisheries Science & Aquaculture,* 2020.

13. **Department of Fisheries**. Catch Assessment Survey Annual Report, Chilanga, Zambia. 2013.

14. **Musumali MM, Heck S, Husken SMC and M Wishart** Fisheries in Zambia: An Undervalued Contributor to Poverty Reduction. The World Fish Center/The World Bank. *Policy Brief,* 1993; 2009.

15. **Aylward B** Freshwater Ecosystem Services. Ecosystems and Human Well-being. *Policy Responses*, 2005.

16. **Braun VJ, Afsana K, Fresco OL, Hassan M and M Torero** Food System Concepts and Definitions for Science and Political Action. *Nature Food,* 2021; **2:** 748–750 www.nature.com/natfoo *Accessed July 2022.*

17. **Maulu S, Hasimuna OJ, Monde C and M Mweemba** An Assessment of Post-Harvest Fish Losses and Preservation Practices in Siavonga District, Southern Zambia. *Fisheries and Aquatic Sciences*, 2020; **23(25):** 1-9. https://doi.org/10.1186/s41240-020-00170-x

18. **Central Statistics.** Zambia Census of Population and Housing. Ministry of Finance and National Planning, Lusaka . 2010.

19. **Cochran WG** Sampling Techniques 3rd Edition.John Wiley and Sons.New York.1977.

20. **Onwuegbuzie JA, Wendy B, Dickinson BW, Leech LN and GA Zoran** A Qualitative Framework for Collecting and Analyzing Data in Focus Group Research. *International Journal of Qualitative Methods,* 2009; **8(3).**

21. **Rabiee F** Focus Group interview and Data Analysis. *Nutrition Society*, (2004), **63:** 655–660 https://doi.org/10.1079/PNS2004399

22. **Hsieh HF and SE Shannon** Three Approaches to Qualitative Content Analysis. *Qualitative Health Research*, 2005; **15:** 9. https://doi.org/10.1177/1049732305276687

23. **Kiruba-Sankar R, Praveen RJ, Saravanan K, Lohith KK, Raymond JAJ, Velmurugan A and R Dam** Invasive Species in Freshwater Ecosystems – Threats to Ecosystem Services. ICAR-Central Island Agricultural Research Institute, Port Blair, India. 2018.

24. **Ballew GN, Bacheler NM, Kellison TG and AM Schuelle** Invasive Lionfish Reduce Native Fish Abundance on a Regional Scale. *Scientific Reports*, 2016. https://doi.org/10.1038/srep32169

25. **Carey PM and HD Wahl** Native Fish Diversity Alters the Effects of an Invasive Species on Food Webs. *Ecology*, 2020; **91(10):** 2965–2974.

26. **Bbole I, Katongo C, Deines MA, Shumba O and MD Lodge** Hybridization Between Non-Indigenous Oreochromis niloticus and Native Oreochromis Species in the Lower Kafue River and its Potential Impacts on Fishery. *Journal of Ecology and the Natural Environment,* 2014; **6(6):** 215-225.

27. **Deines AM, Bbole I, Katongo C, Feder JL and MD Lodge** Hybridization Between Native Oreochromis species and Introduced Nile Tilapia O. niloticus in the Kafue River, Zambia. *African Journal of Aquatic Science*, 2014; 1–12.

28. **International Union for Conservation of Nature IUCN.** Red List Categories and Criteria: Version 3.1. Second edition. Gland, Switzerland and Cambridge, UK: IUCN;2012; iv + 32pp.

29. **Food and Agriculture Organisation.** Socio-Economic and Biological Impacts of Fish-based Feed Industry for Sub-Saharan Africa. Fisheries and Aquaculture circular number 1236.The Food and Agriculture Organisation of the United Nations, 27 WorldFish and The University of Greenwich, Natural Resources Institute, Rome; 2022.

30. **Njiru M, Waithaka E, Muchiri M, Knaap VM and IG Cowx** Exotic Introductions to the Fishery of Lake Victoria: What are the Management Options? *Lakes and Resevoirs,* 2005; **10(3)**. https://doi.org/10.1111/j.1440-1770.2005.00270.x

31. **Kawarazuka N and C Béné** Linking Small-scale Fisheries and Aquaculture to Household Hutritional Security: An Overview Food Security, 2010; **2:** 343–357.

32. **Mussa H, Kaunda E, Chimatiro S, Banda L, Nankwenya B and J Nyengere** Assessment of Informal Cross-Border Fish Trade in the Southern Africa Region: A Case of Malawi and Zambia. *Journal of Agricultural Science and Technology* B 7; 2017; 358-366. https://doi.org/10.17265/2161-6264/2017.05.009

33. **Zambia Statical Agency.** Zambia Population and Housing Census.Ministry of Finance and National Planning, Lusaka; 2022.

34. **Trana N, Chub L, Chana CY, Genschickc S, Phillipsa MJ and AS Shula** Kefi Fish Supply and Demand for Food Security in Sub-Saharan Africa: An Analysis of the Zambian Fish Sector. *Marine Policy*, 2019; **99:** 343-350.

35. **Food and Agriculture Organisation.** Zambia Nutrition Profile – Nutrition and Consumer Protection Division, 2009.

36. **Beveridge MCM, Thilsted SH, Phillips MJ, Metian MM, Troell M and SJ Hall** Meeting the Food and Nutrition Needs of the Poor: The Role of Fish and the Opportunities and Challenges Emerging from the Rise of Aquaculture. *Journal of Fish Biology,* 2013; **83:** 1067–1084. https://doi.org/10.1111/jfb.12187