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# USING COMMUNITY PERCEPTIONS TO ASSESS THE SUSTAINABILITY OF THE LAKE TURKANA FISHERY FOOD SYSTEM

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## ABSTRACT

Sustainable food systems provide food security and nutrition while preserving economic, social, and environmental foundations for future generations. The Lake Turkana Fishery is the second largest fishery in Kenya both by volume and value. With uncoordinated development and lack of proper management, the fishery does not live up to its full potential. Consequently, the Lake Turkana Basin is classified as one of the most food-insecure regions in Kenya. More than half of the inhabitants in the Lake Turkana Basin fall in IPC Phase 3 of food security classification. To understand and come up with development strategies to revitalize the fishery, it is necessary to research the principles guiding management of sustainable food systems. This study's general objective was to determine if the stakeholders of the Lake Turkana fishery appraise it as a sustainable food system. Specifically, the study sought to assess perceptions of the fishing community of different sustainability aspects of the fishery, enumerate community-informed strategies for resilience building, and assess gender issues and power relations. The study used the FAO's Food Sustainability Assessment Framework (FOODSAF) to assess the sustainability scores of the Lake Turkana fishery. The variables measured (both perception measures and the external sociodemographic variables) significantly predicted the sustainability score of the food system ($F(2, 202) = 14.388$, $p < 0.05$), accounting for 62.5% of the variability in predicting the perception score of sustainability of the fishery with adjusted R-squared of 0.616. Based on this, we can conclude that the community perceived the Lake Turkana Fishery to perform quite low in terms of being a sustainable food system. The community embraces the use of traditional and adaptive knowledge as resilience mechanisms in the face of climate change threatening livelihoods. The study also established that gender relations follow strict boundaries that are informed by traditional and cultural gender roles, age, taboos and socioeconomic factors.

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## LIST OF ABBREVIATIONS

| **Abbreviation** | **Definition** |
|---|---|
| ANOVA | Analysis of Variance |
| ASAL | Arid and Semi-arid Lands |
| BMU | Beach Management Units |
| CBCA | Community-based Conservation Area |
| FAO | Food and Agriculture Organisation of the United Nations |
| FOODSAF | Food System Assessment Framework |
| GDP | Gross Domestic Product |
| IPC | Integrated Food Security Phase Classification |
| KNBS | Kenya National Bureau of Statistics |
| SDG | Sustainable Development Goal |
| USAID | United States Agency for International Development |
| USD | United States Dollar |

# 1 INTRODUCTION

## 1.1 Background

The fisheries industry contributes significantly to Africa's development by reducing poverty, supporting socioeconomic progress, and improving the lives of poor and disadvantaged groups. The sector is composed primarily of small-scale fishers. While global inland capture fisheries yield about 6.5% of global reported fish production, a number of studies have shown that this is an understatement and that actual yield may be several times higher (Bartley, et. al., 2015; Finegold, 2009; Jentoft, 2008). The apparent low proportion of fish provided by inland capture fisheries globally does not adequately reflect their importance in societies in developing countries, particularly in the African continent (Chimatiro, Nouala, & Seisay, 2014). The provision of a nutritious and sustainable diet for the anticipated 2.4 billion people by 2050 is one of the most significant concerns confronting food systems on the continent. Governments in Africa have been grappling with, amongst other issues, widespread poverty and protracted food insecurity (Chan, et al., 2021).

Kenya's fishing sector accounted for roughly 2% of the country's total export revenues in 2021 and contributed about 1% to the GDP with its contribution almost doubling from USD 426 million in 2017 to USD 807 million in 2021 (KNBS, 2022; Onsarigo & Nyaboga, 2020). The fisheries sector directly employs over 60,000 fishermen (Kimani, Aura, & Okemwa, 2018). 164,000 metric tonnes of fish catches were landed in 2021 in Kenya, valued at slightly above USD 300 million. Inland capture fisheries accounted for 83% of this volume and 77% of the total value. Lake Victoria, the world's largest inland freshwater fishery, contributed 69% to the total catches, while Lake Turkana, the world's largest permanent desert lake, contributed 11.5%. The main commercial fish species from Kenya’s inland freshwater fisheries are *Rastrineobola agentea* (Omena), *Lates niloticus* (Nile perch), *Oreochromis niloticus* (Nile tilapia), *Cyprinus carpio* (Common carp), and *Micropterus salmoides* (Black bass). At the same time, the dominant marine capture landings are made up of *Siganidaœ* (rabbitfish), *Lutjanidae* (snappers), and *Scaridae* (parrotfish).

## 1.2 Challenges facing the Lake Turkana fishery

As shown in Figure 1 below, Kenya's capture fishery peaked in the 1990s to over 200,000 metric tons but subsequently dropped to below 120,000 tons in 2002. This was attributed to the decline of the Nile perch fishery in Lake Victoria (Kimani et al., 2018). Climate change, environmental unpredictability, invasive species, overfishing, dwindling stocks, and substantial post-harvest losses contribute to the demise of inland capture fisheries (Muringai, Mafongoya, & Lottering, 2022). This underutilization represents a significant shortfall in terms of nutrition and economy for the region. According to the Fish Sector Development Strategy for Kenya, increased productivity is possible in the fisheries industry, notably in the marine fisheries and in inland fisheries with Lake Turkana being specifically pointed out as one of these key areas for expansion (Wakwabi, Mbithi, & Abila, 2003). Increased productivity could be realized through improved accessibility and infrastructure development, enhanced offshore exploitation through provision of credits to fishermen wishing to engage in offshore fishing, reduction of post-harvest losses through better handling and storage facilities and lastly regular stock assessment to determine sustainable levels. Over time, management interventions have been created to address this, primarily the establishment of co-management structures like Beach Management Units (BMUs) and Community-based Conservation Areas (CBCAs), which are charged with overseeing fishing operations and the preservation of the local environment as well as the creation and implementation of local fisheries management plans. Beach Management Units (BMUs) in Kenya were established as co-management institutions to ensure sustainable utilization and management of fishery resources at landing sites (Tubman, Muigua, & Muthama, 2021).

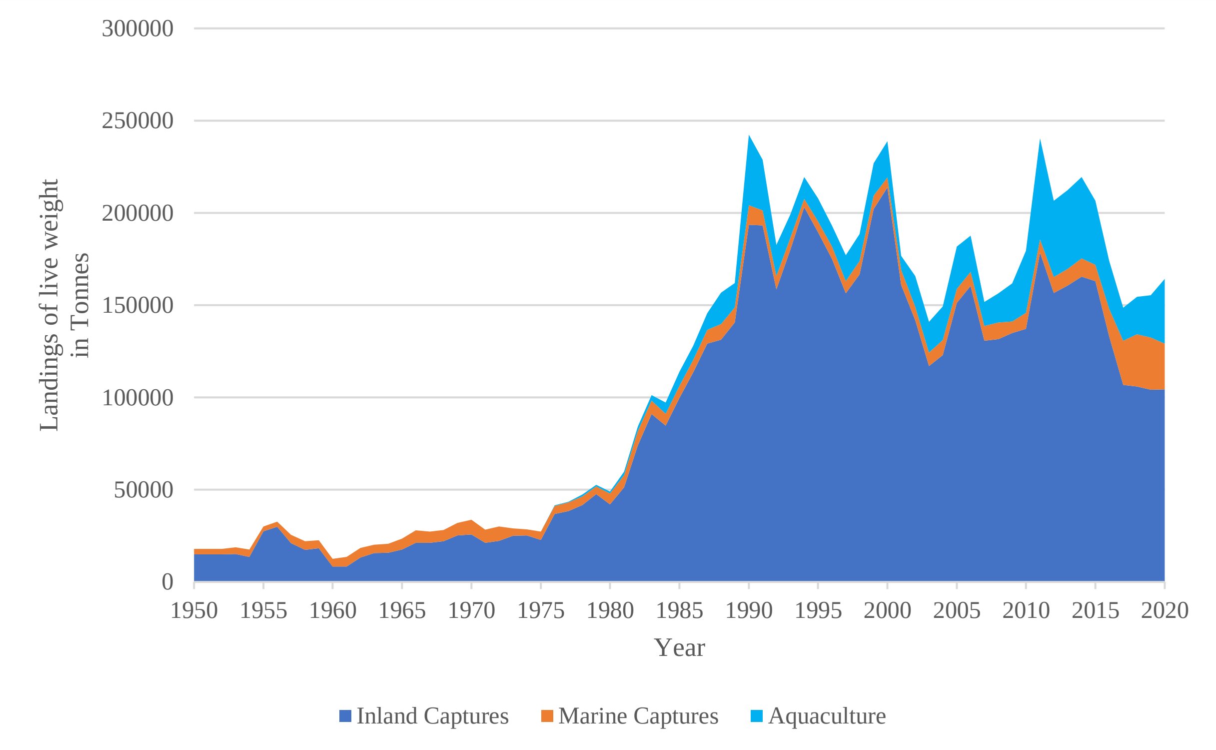


Figure 1: Kenya's fish production comparing inland capture, marine capture, and aquaculture between 1950 to 2020 (FAO Fisheries Statistics).

To achieve the nation's National Agenda for Achieving Nutritional and Food Security, efforts to reduce postharvest loss, improve processing, and add value have been stepped up. For the catch fishing industry to develop more quickly, infrastructure investments in land-based fish handling and value-added services, as well as stock and water quality monitoring, are essential. Fisheries and aquaculture offer ample opportunities to alleviate poverty (SDG1), to reduce hunger and improve nutrition (SDG2) and contribute to good health and well-being (SDG3). Kenya's Vision 2030 development objectives are also being supported by the country's aquatic resources, particularly its capture fisheries. Kenya’s Blue Economy program also acknowledges the critical contribution of marine-based activities to Kenya's economic growth and food security (Rasowo, Orina, Nyonje, Awuor, & Olendi, 2020). The program aims to save Kenya's coastal ecosystems while generating jobs and growth across a variety of sectors, including tourism, recycling, and small-scale fishing. It is intended to promote a blue economy that is sustainable in Kenya's coastal counties and result in the creation of jobs for women and young people. The project will develop new work streams, such as small-scale fisheries, waste recycling, aquaculture, tourism, as well as technical skills in blue economy sectors, while strengthening value chains and addressing regional bottlenecks. It will also bring inclusive, integrated, and sustainable approaches to economic growth. Additionally, it will support coastal counties' initiatives to create integrated land-sea planning and management frameworks with an emphasis on recovering important coastal and marine ecosystems. As a result, timely data and information on the state of the fishing stocks and related ecosystems are essential for planning future development and supporting the sustainable management of fisheries resources.

## 1.3 Problem statement

In recent years, both academics and policymakers have given increased attention to the idea of the food system (Béné et al., 2019). Particularly, experts from all fields and backgrounds have addressed the nature and causes of the unsustainability of our contemporary food systems. However, these initiatives typically take place inside specific disciplinary narratives. Food systems are social–ecological systems, formed of biophysical and social factors linked through feedback mechanisms (Pereira, et. al., 2020). These activities cover social, economic, political, institutional, and environmental processes and dimensions, referred to as scales.

A sustainable food system ensures that food security and nutrition are attained while maintaining the economic, social, and environmental foundations necessary to ensure those same conditions for future generations. This implies that such a food system is consistently profitable, ensuring economic sustainability, has widespread societal benefits, ensuring social sustainability, and has a favourable or neutral influence on the environment's natural resource base, ensuring environmental sustainability (Capone, Bilali, Debs, Cardone, & Driouech, 2014).

Issues concerning the food system include the governance and economics of food production, its sustainability, the degree to which we waste food, how food production affects the natural environment and the impact of food on individual and population health. Concerns about sustainability in food systems span several areas, including governance or policy, consumption patterns, technology, information, and socioeconomic and food security factors. This study aimed at assessing the sustainability of the Lake Turkana Fishery as a Local Food System. The fisheries confront several risks, including upstream water appropriation for hydroelectric production and cultivation. As a result, habitat degradation, biodiversity loss, pollution, and tribal conflicts have occurred. These dangers are exacerbated by climate change, agriculture, forest destruction, and the possible exploitation of oil resources. Occasioned by a lack of proper management of the fishery and uncoordinated management by stakeholders and the local community, the fishery does not live up to its potential. As a result, inhabitants of the Lake Turkana Basin have been continually categorized as acutely food insecure (Burns et al., 2022) and this always raises questions as to whether the fishery can be deemed sustainable or not.

## 1.4 Justification of the study

Despite the Turkana Basin boasting of the 8000km$^2$ Lake Turkana Fishery, the second largest fishery in Kenya, the basin is classified as one of the most food-insecure regions in Kenya. Studies have established that key institutional stakeholders such as the local community, fishers and environmental regulatory bodies have not been included in supporting specific areas of co-management for the sustainable management of the Lake Turkana Fishery (Ogoma, et. al., 2019). Despite being in an acutely food-insecure region, literature shows that the fishery needs to be sustainably explored for increased food production and utilization (H. C. Bironga, Ongeri, & Aura, 2022). Lake Turkana fishery is under-exploited because fishing practices are mostly artisanal, there are poor infrastructural amenities in terms of roads, electricity and storage facilities, only obsolete technologies are available for product handling and processing, and communities are distant from viable markets (Aloo, 2006). To revitalize this fishery, there is need for enhanced stakeholder engagement by assessing the community's perceptions on the performance of the food system to deduce areas of strength and weaknesses. This will offer policy direction for management and prioritization.

## 1.5 Objectives

### *1.5.1 General Objective*

The study's general objective is to determine if the stakeholders of the Lake Turkana fishery appraise it as a sustainable food system.

### *1.5.2 Specific Objectives*

Effectively, the specific objectives of these study include:

i. To determine the community perceptions of different sustainability aspects of the Lake Turkana Fishery.
ii. To enumerate community-informed strategies for resilience building of the Lake Turkana Fishery.
iii. To assess gender issues and power relations in the various value chain nodes of the Lake Turkana Fishery.

## 1.6 Limitations and scope of the study

The scope of this study is to cover the perceptions that the fishing community of the Lake Turkana Basin hold on the fishery as regards its sustainability as a food system. This will inform strategies for resilience building in the face of climate change related impacts such as habitat degradation, biodiversity loss, rising lake water levels, erratic weather patterns, damming of inflowing water upstream, pollution, and water abstraction. Their perceptions of the sustainability of the fishery will be informed by their vast indigenous knowledge. This makes some of the perceptions highly subjective. It is also worth noting that the literacy levels of communities in the lake basin are very low (Mkutu, et. al., 2019). Lake Turkana fishery is in the Turkana Basin, which is highly inaccessible due to a need for properly functioning infrastructural systems. The only means of transport and travel in the basin is by using dirt roads rendered unusable during the rainy or flooding seasons. This is partly why the study was almost exclusively conducted on the western shores of Lake Turkana. The other reason for the study being conducted on the western shores is that the eastern coast is less exposed, more rugged, and rocky, with a few sheltered bays. Besides, the eastern coast generally has poor shore vegetation due to the combined effect of strong winds, fluctuating water levels, and grazing by domestic animals, as the communities on this coast are predominantly agro-pastoralists (Kolding, 1992). Consequently, fishing activities on the eastern shores of the lake are almost non-existent.

# 2 LITERATURE REVIEW

## 2.1 Introduction

According to Goodland & Daly (1996), environmental sustainability is a term distinct from yet related to social and economic sustainability. Many agri-food production and consumption models have raised concerns about the impact of various food systems on local development procedures, particularly regarding the economic exploitation of rural regions and environmental, cultural, and social elements. In addition to the actual production of food, most models tend to concentrate on farm-to-market systems for regional, high-quality, sustainable products, as well as how food systems respond to new and developing requirements of both rural and urban people (Peano, Migliorini, & Sottile, 2014).

The Food and Agriculture Organisation (FAO) has a mandate to improve nutrition, increase agricultural productivity, raise the standard of living in rural populations, and contribute to global economic growth. In order to meet its mandate, it established a handbook to improve the gathering of more precise data and good guiding principles on the sustainability of food systems (FAO, 2020). According to the institution, food systems are the prime connection between people and the planet, and as such, they can help achieve multiple Sustainable Development Goals (SDGs) (FAO, 2018). The manual offers a thorough methodology that considers the interdependencies and complexity of sustainability components while evaluating and implementing crop, livestock, fisheries, aquaculture, and forestry enterprises to build a standard framework for evaluating sustainability.

## 2.2 The Food Systems Sustainability Assessment Framework (FOODSAF)

A food system is defined as everything that goes into producing, transporting, distributing, manufacturing, storing, selling, and consuming food, as well as the effects these actions have on society, the environment, and our health (Ericksen, 2008). Food systems analysis is based on a systematic evaluation of the various underlying processes that influence food availability, access, and utilisation, as well as a detailed examination of the roles of the various stakeholders involved, particularly the role of the consumer in nutrition-oriented food systems (Ruben, Verhagen, & Plaisier, 2019). The analysis requires a thorough understanding of a food system's structure as well as the dynamics of food system changes over time and space in relation to predefined societal, environmental and distributional goals. However, the sustainability concept has wide interpretation from the perspective of different researchers and or food system players (Caron, Biénabe, & Hainzelin, 2014; Hinrichs, 2003; Morris et al., 2021). Through interactions with the food system landscape and players involved in the food system, we get an opportunity to understand different facets of the food system, from production, processing, distribution, storage, marketing, consumption, and disposal of foods for a clear understanding of the constituent components of sustainability and how strengths, weaknesses, and progress could be assessed. The Food System Assessment Framework (FOODSAF) is a list of key principal indicators of a sustainable food system that details important food system traits and specific steps for developing an assessment of a given food system by providing a conceptual and empirical structure to guide evaluation on the performance of that food system in the different indicators.

A food system should support local, regional, national, and international collective efforts to affect positive change in satisfying people's food needs and meet the economic, social, and environmental sustainability components. As a result, a sustainable food system ensures food security and nutrition for all population members without compromising the economic, social, and environmental foundations necessary to ensure food security and nutrition for future generations (Nguyen, 2018). This means that a sustainable food system meets three important criteria:

i. Economic sustainability, that is, it is profitable throughout.
ii. Social sustainability, that is, has broad-based benefits for society.
iii. Environmental sustainability, that is, it has a positive or neutral impact on the natural environment.

A FOODSAF will generally identify several key steps to be followed iteratively by identifying the problems faced by a given food system, defining the scope of those problems, identifying the scenario, conducting analysis of the scenario, synthesizing the findings, and reporting to stakeholders of that food system. The FOODSAF generally has five indicators with sub-themes, as shown in Table 1 below:

Table 1: Parameters used to assess a food system's sustainability based on user perceptions and experiences (von Braun, Afsana, & Fresco, 2021).

| INDEX | KEY THEME | SUB-THEME |
|---|---|---|
| 1 | Socio-ecological resilience | Diversity of the food system |
| | | Social self-organization |
| | | Ancestral knowledge |
| 2 | Food security | Household food security |
| | | Power relations |
| | | Capacity to process and store food |
| 3 | Environmental performance | Environmental benefits |
| | | Carbon footprint |
| | | Impacts on human health |
| 4 | Right to food | Non-discrimination |
| | | Access to information |
| | | Effective participation in the food system |
| 5 | Poverty and inequality | Sources and levels of income |
| | | Access socio-technological infrastructure |
| | | Performance of the value chain |

### 2.3 The need to assess fisheries for sustainability

The conservation of fishing resources to ensure their sustainability is a shared concern of the global society. The worldwide fisheries management system was formed before the turn of the century and is based on the United Nations Convention on the Law of the Sea (UNCLOS) of 1982 (Zhang, 2021). The international community has established several legally binding and non-binding policy tools to implement the global fisheries regime to guarantee sustainable fisheries management. Fisheries management is characterized by various competing goals, several parties with conflicting interests, and a high degree of ambiguity about the dynamics of the resources being managed (Nichols et al., 2011).

On the one hand is the need to increase the stock biomass, which entails restrictions on the resources, while on the other is the need for increased harvests driven by a growing population and drive for increased profitability. In addition to the general public's concern about performance, fisheries-management organizations have also had to contend with opposition from the fishing industry on several topics, not the least of which is opposition to the scientific justification for the limits used to maintain stocks. A move to involve industry and other stakeholders far more in the management process has been one of the responses to these worries.

This strategy is co-management (Jentoft, 1989; Smith, Sainsbury, & Stevens, 1999; Urquhart, Acott, Symes, & Zhao, 2014).

## 2.4 Research Gaps

Multiple studies have shown the shortcomings of the existing food systems and how they relate to larger socioeconomic inequities (Allen, 2010; Born & Purcell, 2006; Figueroa, 2015). As such, we know quite well what food justice, food sovereignty, and sustainable food systems are. This means that we know what concepts these terms entail. It also means that in the absence of the concepts, we can’t term food injustice or lack of food sovereignty. It is necessary to research the principles guiding sustainable food systems. This study will employ the FOODSAF theoretical framework since it de-centres food in the study of food systems (Koberinski, Vivero-Pol, & LeBlanc, 2022), making social life the primary factor that guides choices in all aspects of the food system, from inputs to production, handling, and processing, harvesting, distribution, and consumption. This is particularly important for the Lake Turkana Fishery. More than half of the inhabitants in the Lake Turkana Basin are classified as being in severe or worse food security situation (IPC Phase 3) according to the latest Integrated Food Security Phase Classification, and acute malnutrition is reported in the region (Government of Kenya, 2022; Stevenson & Buffavand, 2018).

## 2.5 Conceptual Framework

This study uses the theory of change for transforming food systems under climate change, as proposed by (Campbell et al., 2018), to assess the sustainability of the Lake Turkana fishery. Under this theory, the study will enumerate five key areas and how the community perceives the fishery's performance in the areas to determine the fishery's sustainability score. The five factors are related, as shown in Figure 2 below.

Socio-ecological resilience of a food system entails factors such as diversity in the food system, the capacity of food system players to aggregate their outputs and assets for a bigger market, and the use and transfer of indigenous knowledge in driving productivity (Thompson & Scoones, 2009). These three factors are key in resilience building as they outline a community's available options, social self-organization, and ability to use available tools to predict weather and migration patterns. It also informs the post-harvest handling practices available to a community and innovations to cut on post-harvest losses.

Under environmental performance, the study will look at three factors. These are the carbon footprint of factors of production on the food system, environmental benefits derived from the food system, and the impact of the food system on the human health of the community (Chaudhary, Gustafson, & Mathys, 2018). Population health is a key factor in addressing food systems challenges, especially since nutrition-related chronic diseases such as obesity, diabetes, cardiovascular disease, and some forms of cancer are major contributors to the global burden of disease. As for the assessment on Food Security, the study will assess the community perceptions of the contribution of the food system to household security, power relations between players in the food system concerning gender, age, and cultural differences, and lastly, the capacity of the food system to process, store and distribute fish (Allen, 1999).

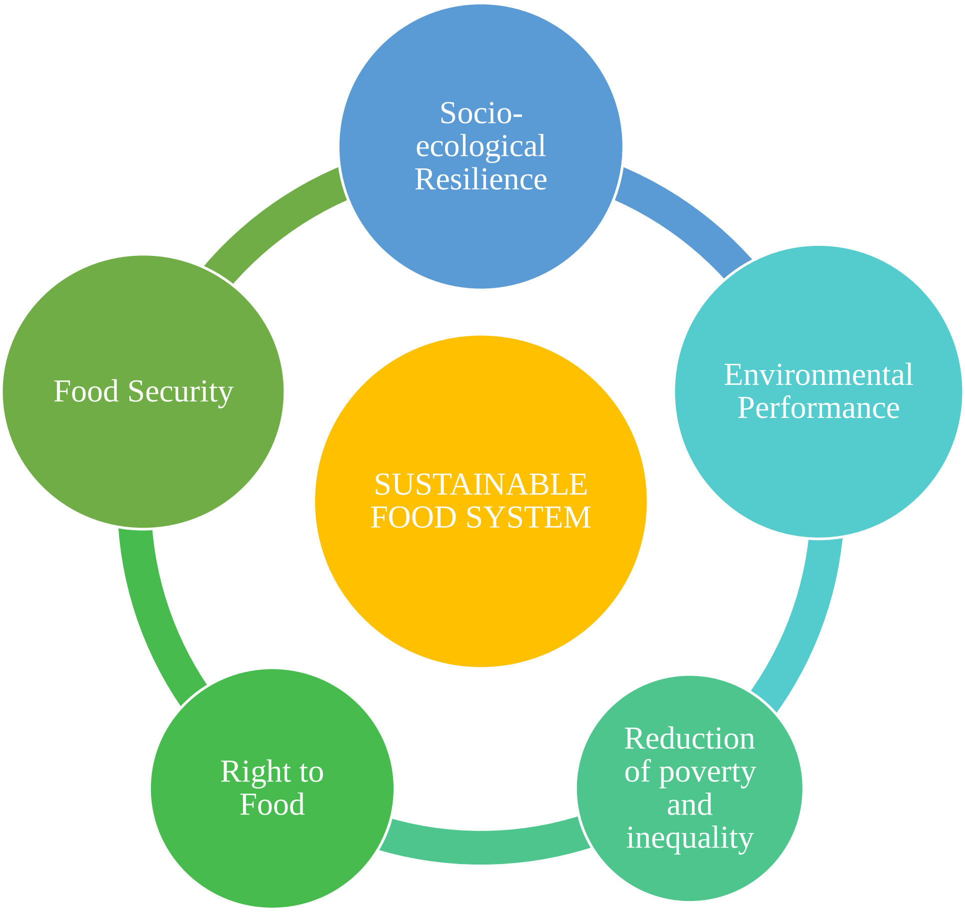


Figure 2: Food Systems Sustainability Assessment Framework based on the Theory of Change for transforming Food Systems.

The study will also enumerate the community's perceptions of the fishery's role in attaining food rights. The right to food entails innovative financing and access to leverage public goods (Rae, Thomas, & Vidar, 2007). Under this, all stakeholders' access to information, effective participation, and non-discrimination will be assessed. Lastly, the study will assess the fishery's contribution to poverty and inequality. This will be studied by taking the community's views on the performance of the fishery value chain, the community's access to socio-technological infrastructure, and the other available income sources and income levels.

# 3 METHODOLOGY

## 3.1 Study Area

The research was carried out in Kenya's Lake Turkana Fishery as shown in Figure 3 below. The fishery is centered on Lake Turkana, which is Kenya's second-largest fishery with a surface size of approximately 7,560 $km^2$ (Ojwang et al., 2016). Lake Turkana is the world's largest permanent desert lake and Kenya's largest inland lake with an effective surface water drainage area spanning 130,860$km^2$ (Avery, 2012) - a geographical area larger than ninety-seven countries in the world. Notably, Lake Turkana is the largest lake in Kenya, the fourth largest lake in Africa, and the largest desert lake in the world. It is a transboundary resource in the Arid and Semi-Arid Lands (ASAL) of Kenya's northwestern frontier. The regions that surround Lake Turkana share borders with Ethiopia, South Sudan, and Uganda. The trans-boundary Lake Turkana basin, which has a huge catchment area and crosses three of Kenya's five international borders, is mostly made up of the Omo River and Lake Turkana and is shared by three Kenyan counties: Turkana, Samburu, and Marsabit. The northern end of the lake is dominated by the Omo Wetland and it is shared with Ethiopia. The Omo River, which originates in the Ethiopian highlands, supplies approximately 90% of the lake's water, with the remainder coming from the Turkwel and Kerio rivers, as well as smaller seasonal rivers in Kenya (Lautze, McCartney, & Gibson, 2022).

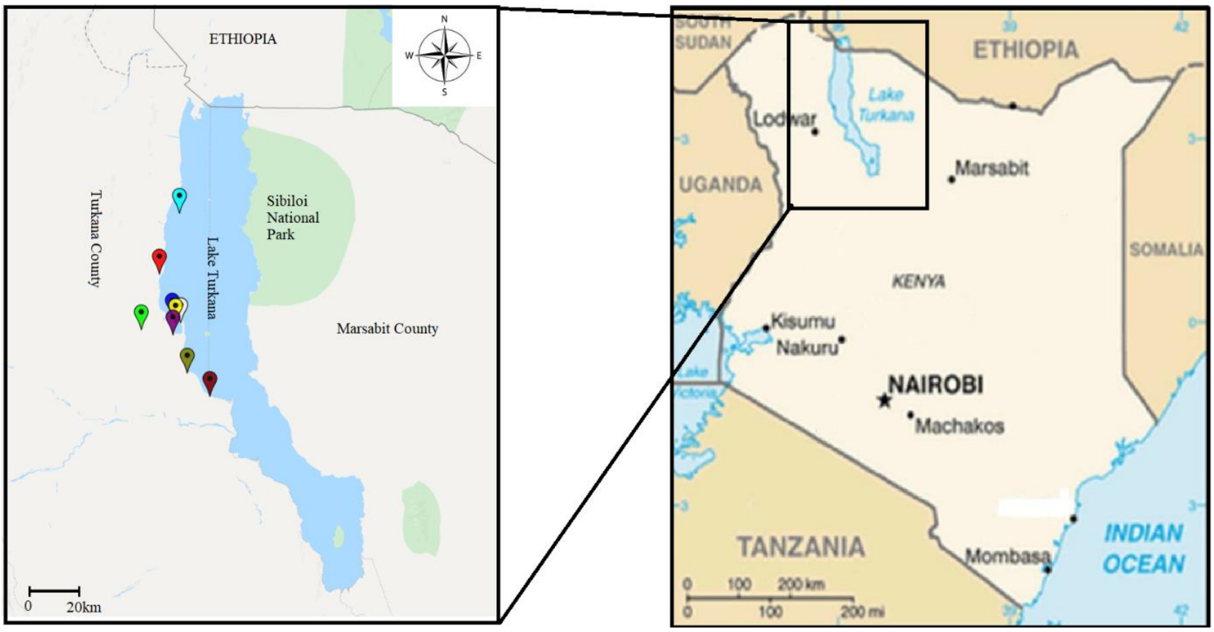


Figure 3: Map of the Lake Turkana Fishery within Kenya, showing the sites where the Beach Management Units (BMUs) are located.

The 2019 census population in Kenya's three counties adjoining Lake Turkana had Turkana County at 927,000 people, Samburu County at 310,000 people and Marsabit County at 460,000 people. Of the above combined total, about 400,000 people are within census sub-locations abutting Lake Turkana, with 250,000 people estimated within the immediate lakeshore zone (Kenya National Bureau of Statistics, 2019). Around 300,000 people depend directly or indirectly on the Lake Turkana Fishery for their livelihoods and nourishment. Population trends have also been observed to double every 20 years in the Lake Turkana Basin. Pastoralism has historically provided the people of the Lake Turkana Basin with a suitable desert zone subsistence, along with agro-pastoralism in the Lower Omo and along the Turkwel and Kerio rivers, as well as fishing in the Lake and Omo River (Avery, 2012). However, fishing in the lake is conducted solely for subsistence, and the lake's fish resources are consequently considered underutilized. The fisheries are threatened by hydroelectric generation and water withdrawal for upstream irrigation, habitat degradation, biodiversity loss, pollution, tribal conflicts, and climate change (Gownaris et al., 2017). Other challenges facing the fishery include high post-harvest fish losses, uncoordinated development approaches, over-exploitation of some lake areas and weak links between research, management, and other sector players.

## 3.2 Research Design

This is a quantitative study. Food security, the right to food, environmental performance, reduction of poverty and inequality, and social-ecological resilience were analysed using a framework of food sustainability. The Lake Turkana Fishery Food System establishes critical indicators for each dimension, and respondents scored their views and experiences of the five aspects of the fisheries' food system based on their encounters with the system's many dimensions.

### *3.2.1 Sampling Strategy*

Stratified sampling was applied. The fishery was classified into four geographical areas that are based on Kenyan administrative units called wards. Wards are the smallest electoral divisions in Kenya and closest the citizens can get government services. This study was conducted in Nariokotome Ward (Zone 1), Kalokol Ward (Zone 2), Longech Ward (Zone 3) and Kang’athotha Ward (Zone 4). The wards run north to south, as the long body of Lake Turkana drops down along the Rift Valley as can be seen in Figure 3. Stratification is appropriate in this case because of the diverse characteristics of the focus groups. Using stratified sampling increases the study's generalizability and validity and eliminates research biases such as under-coverage bias. The stratified sample consists of individuals from each category, ensuring that it accurately represents the variety of the community. This study takes into consideration various socio-demographic parameters of the study population including age, level of education, household size and role in fisheries.

After this, purposive sampling was used to identify the Beach Management Units where focus group discussions were held. Purposive sampling technique allows the researcher to select objectives and specially qualified respondents or participants to collect the requisite data (Etikan, Musa, & Alkassim, 2015). Purposive sampling is appropriate in this case because the volumes of fish landed by the different beach management units vary. The population density also varies within the fishing region due to the area's geography. Some areas were not easily accessible due to a lack of road infrastructure; therefore, the focus was on the easily accessible areas. The security situation of the study area also affected the choice of Beach Management Units that were used to host the focus group discussions. Questionnaires were administered to members of the sampled BMUs in the four zones identified. The interviews followed a set of specific questions, which were worked through systematically according to the conceptual framework given in Figure 2.

### *3.2.2 Pilot Testing Procedure*

The piloting exercise is critical as it helps in identifying any glaring omissions or commissions that the questions in the questionnaire might have or might have been missed (Addington-Hall, Bruera, Higginson, & Payne, 2007). In the process, the pilot test gives us insights on how well the questions will go about realizing our objectives of the research. A pilot test was conducted before the actual research. This pilot test was meant to evaluate the efficacy of the questionnaires regarding their validity and reliability to the study. During the piloting exercise, we administered 10 questionnaires to assess whether any changes needed to be made in how the questionnaire had been structured. It also enabled us to know how the questions would address the research objectives, particularly objectives one and three. The second objective was to be addressed by use of qualitative responses that would be collected during the administration of the questionnaire.

### *3.2.3 Sample Size and Data Collection*

To determine the sample size, we used the Cochran formula (Cochran, 1977) as follows:

$$x = Z^2 pq$$

Where:

- Z is the critical value for the confidence level of the study. For this study, we used a confidence level of 95% and thus the critical value is 1.96.
- p is the (estimated) proportion of the population which has the attribute in question. Because we didn't know how the respondents were distributed, the Cochran formula let's this figure be 50% as it gives the largest sample size.
- q is 1 – p.

To arrive at the desired sample size, we substitute Equation 1 above into Equation 2 below:

$$n = \frac{Nx}{(N-1)E^2 + x}$$

Where:

- N is the population size. As described earlier in the methodology, the lake basin is home to around 250,000 as per the 2019 census figures.
- E is the margin of error for the study. We chose a margin of error of 10%.

Table 2: Sample size determination at different confidence levels using Cochran (1977) formula.

| | Confidence Level | | |
|---|---|---|---|
| | 90% | 95% | 99% |
| Margin of error (E) | 10% | 10% | 10% |
| Population size (N) | 250,000 | 250,000 | 250,000 |
| Response distribution (p) | 50% | 50% | 50% |
| Calculated Sample Size | 68 | 97 | 166 |

Using the Cochran formula above, a sample size of 100 would give a 9.8% margin of error, 200 respondents would give 6.9% and 300 respondents would give 5.7%. All these margins of error are within the 10% margin of error that the study was willing to take (Table *2*). Though 300 respondents would have given the study the least margin of error, taking into consideration limiting factors such as funding, the improvement from 200 respondents was deemed negligible. Thus, the study settled on administering 250 questionnaires speculating on a response rate of between 10% to 20%. This would enable the study to have 200 responses for data cleaning and collation. These questionnaires were administered in a pro-rated manner taking into consideration the size of the fisher community registered in the four study zones.

To go about questionnaire administration, we first held Focus Group Discussions with members of the sampled Beach Management Units in the four zones. During the focus group discussions, we engaged the respondents on the data collection tool (the questionnaire) to familiarize them with the key dimensions and how they were to score their rankings in the questionnaire. To ensure that all respondents were certain of every aspect of the questionnaire, we used an open engagement session, in which we strove to explain what each parameter entailed. The use of vernacular was deemed the best way to make every respondent understand the concepts. After thoroughly discussing an aspect and being satisfied that every participant was fully cognizant of what was being measured, we would then ask each member to independently score an aspect. Each respondent was urged to give their rankings for each dimension based on their perceptions, personal experiences and interaction with the Lake Turkana Fishery as a food system.

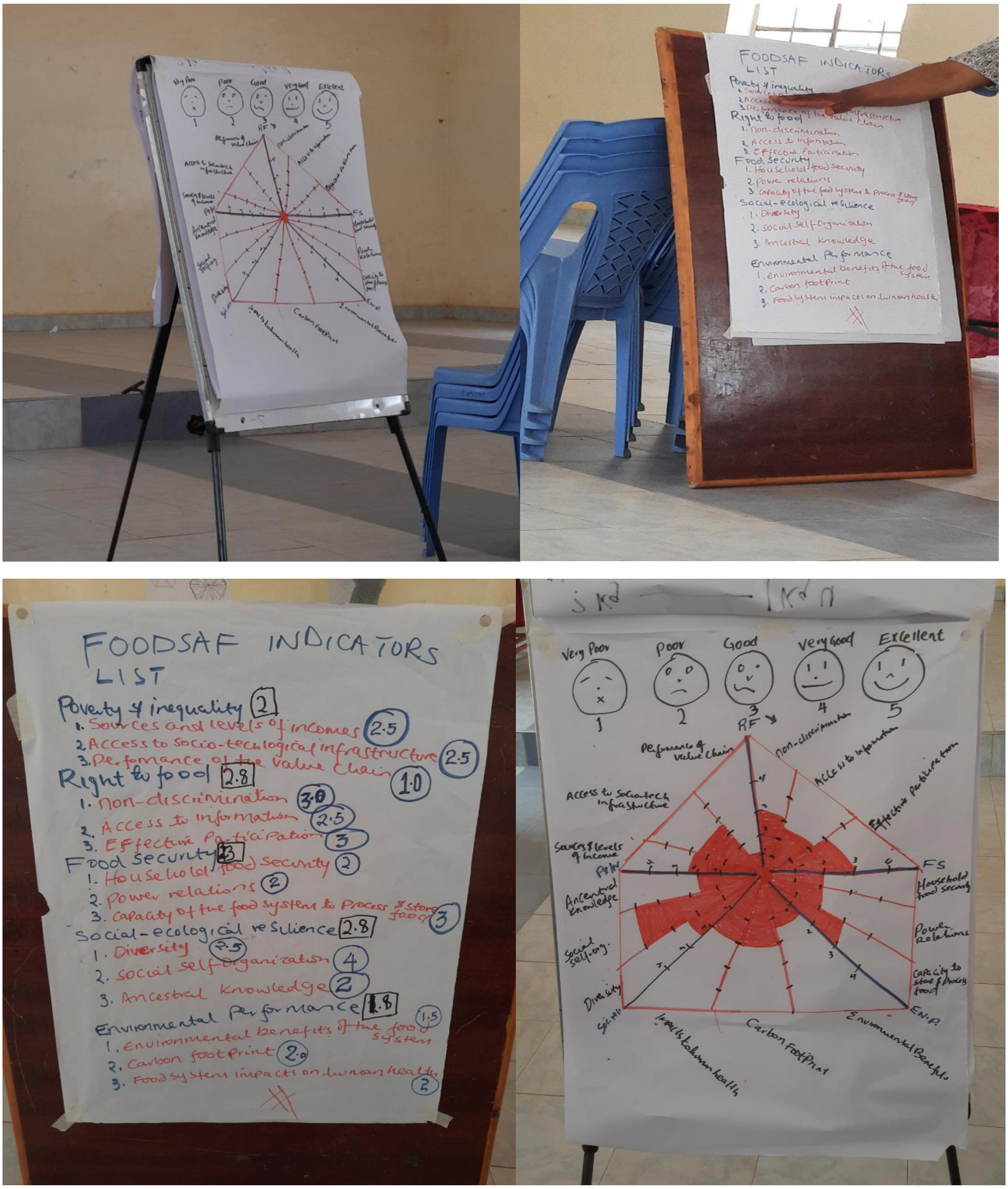


Figure 4: Images documenting one of the Focus Group Discussions for collection of data.

### 3.3 Data Processing and Analysis

Based on the five key dimensions, food sustainability scores for the food system were subjected to a Likert Scale. The highest score (5) indicated the highest score of perception for sustainability (EXCELLENT), while the lowest score (1) indicated the lowest score of perception for sustainability (VERY POOR). 2 indicated POOR, 3 indicated GOOD, and 4 indicated VERY GOOD. The data was coded using both R and Excel to enable analyses on both the software and on SPSS.

Likert scale data is classified as ordered-categorical data. This means that correlational analyses won't give the best results for this kind of data since correlation only tests monotonicity in linear relationships (Lubke & Muthén, 2004). Categorical data poses the challenge of making the power of respondents dissipate very fast. To address this, we subjected our data to ordered logistic regression. This is because the ordered logit is vital in weighting the marginal contribution of the responses to the different factors whose perceptions were being measured (Endresen & Janda, 2015). Ordinal logistic regression (often just called 'ordinal regression') is used to predict an ordinal dependent variable given one or more independent variables. It can be considered as either a generalisation of multiple linear regression or as a generalisation of binomial logistic regression. We also conducted non-parametric analyses of ordinary averages of Likert scale data because this is justifiable by the Central Limit Theorem (Norman, 2010). For this analysis of variance, we used the analysis of variance (ANOVA) technique and other regression procedures. For the two independent variables of sex, male and female, the data was subjected to Chi-square tests. This is because Chi-square is more flexible to this kind of ordered tests (Jolliffe & Primo, 2008). Using R, SPSS and Microsoft Excel, data summaries were generated as frequencies, means, and percentages and presented in tabular forms and charts.

### 3.4 Validity and Reliability of Research Instruments

Many of the essential variables and outcomes in social science research are abstract ideas referred to as theoretical constructs. A key element of research quality is the use of reliable and valid tests or instruments to measure these components (Kimberlin & Winterstein, 2008). The goal of research validity is to ensure that the research measures what it claims to measure. Validity concerns are on what the instrument measures and how well it does so. Meanwhile, reliability is concerned with the research instrument’s consistency to deliver the same results when conducted periodically under the same conditions. The reliability concerns justify the validity of the research as it reveals how consistent the instruments measure what is intended to. Reliability analysis was conducted to check the homogeneity between variables. Cronbach’s alpha coefficient was used to determine the reliability and internal consistency of the 15-item Sustainability scale. This is because Cronbach's α is the most widely used index for measuring the reliability of a scale (Streiner, 2003).

### 3.5 Hypothesis Testing

Using the perception scores, the study sought to establish if the Lake Turkana Fishery was thought of as a sustainable food system by local stakeholders.

# 4 DATA ANALYSIS AND RESULTS

## 4.1 Response Rate

A response rating is a value that is used to represent the number of participants who took part in the study and offered informed data as expected by the researchers. The response rate is derived from the sample size that took part in the evaluation study. In this study, a total of 240 questionnaires were administered of which 212 were fully answered. But after data cleaning and collation, only 205 were deemed satisfactorily answered and thus used for data analysis as indicated in Table 3.

Table 3: Response Rate for Questionnaires administered.

| Zone | Questionnaires administered | Questionnaires fully answered | Response Rate | Questionnaires used for Analysis |
|---|---|---|---|---|
| 1 | 30 | 26 | 87% | 26 |
| 2 | 100 | 92 | 92% | 91 |
| 3 | 80 | 70 | 88% | 66 |
| 4 | 30 | 24 | 80% | 22 |
| **Total** | **240** | **212** | **88%** | **205** |

## 4.2 Socio-demographic Variables

In terms of geographical distribution, 12.7% of the respondents were from the Northern Fishery (Zone 1), 44.4% were from the Kalokol Area (Zone 2), 32.2% were from the Ferguson's Gulf Area and 10.7% were from the Southern Fishery (Zone 4) as shown in Table *4*. Most of the respondents were between the age group 36-45 years while most respondents had at least a secondary education. While males represented the biggest demographic in almost all age groups, females were slightly more than males between the ages of 46 to 55 years. However, combining those who had dropped out of school at lower primary school level, most of the respondents were those who had just a primary school education. As for the distribution of female respondents, most females were in the age group between 36 to 45 years (Figure *5*).

Table 4: Distribution of respondents according to the study sites

| Zone | Sex | | Average Age | Education Levels | | |
|---|---|---|---|---|---|---|
| | **Male** | **Female** | | **Primary School** | **Secondary School** | **Tertiary Studies** |
| 1 | 18 | 8 | 34.7 | 14 | 12 | 0 |
| 2 | 64 | 27 | 45.5 | 38 | 29 | 24 |
| 3 | 47 | 19 | 40.3 | 33 | 23 | 10 |
| 4 | 18 | 4 | 37.8 | 8 | 11 | 3 |
| **Total** | **147** | **58** | | **93** | **75** | **37** |

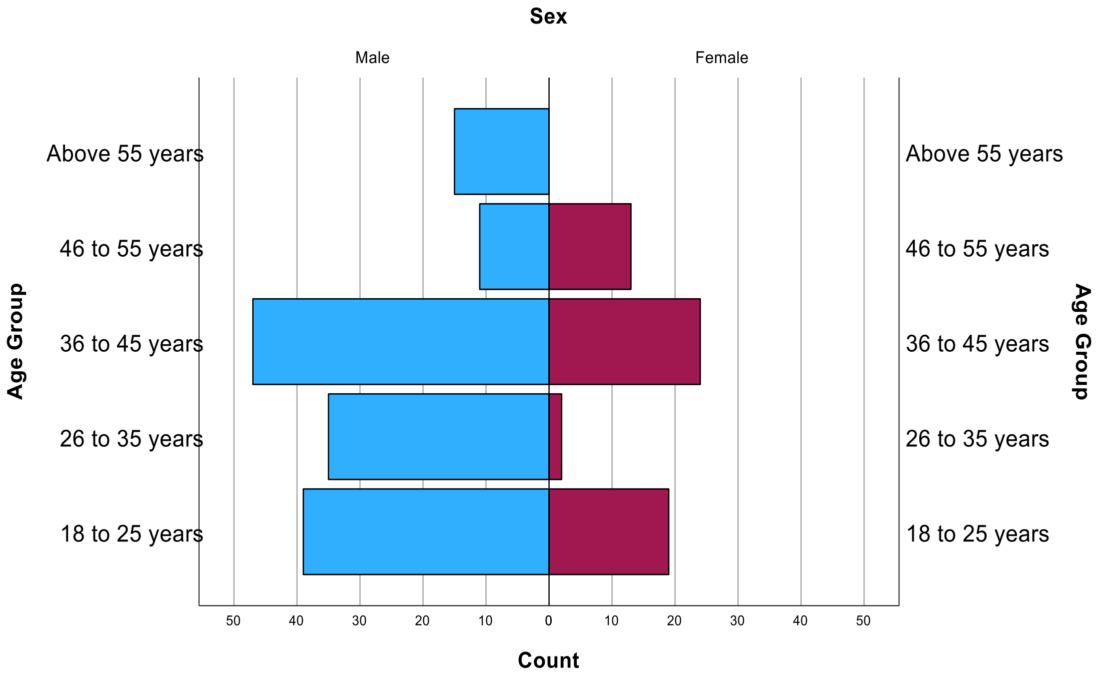


Figure 5: Bar graph showing distribution of respondents according to age, sex, and level of education.

## 4.3 Correlations and Reliability Statistics

### *4.3.1 Correlation between socio-demographic variables and perception measures*

Amongst the socio-demographic variables, the study did not find any correlation between sex and the variables of age group, level of education and the years a member had stayed in the fishery (Table 5). Age group had a very high correlation ($r = 0.96$, $p = 0.000$) which was statistically significant and slightly positive correlation with the length of stay in the fishery ($r = 0.25$, $p = 0.000$). A member's level of education also had a statistically significant positive albeit weak correlation with the years of experience spent in the fishery ($r = 0.24$, $p = 0.001$).

In terms of correlation between the sociodemographic variables and the perceptions that were being assessed, age group had a weak positive correlation with perceptions on performance of the value chain ($r = 0.16$, $p= 0.019$) and perception on the food system's impact on human health ($r = 0.19$, $p= 0.008$) but negatively weak correlation with perceptions household food security derived from the fishery ($r = -0.15$, $p= 0.032$). The level of education of a respondent was found to have weak positive correlation with the perceptions of the performance of the value chain ($r = 0.17$, $p= 0.018$), access to information ($r = 0.14$, $p= 0.049$) and the food system's impact on the health of the local community ($r = 0.15$, $p= 0.032$). Years of experience spent in the fishery's trade had a statistically significant positive correlation with the perception of the fishery creating more sources and levels of income ($r = 0.21$, $p=0.003$) and the perception on accumulation of ancestral knowledge ($r = 0.17$, $p=0.018$).

Table 5: Correlation between socio-demographic variables and study perception Measures.

| | | Sex | Age Group | Level of Education | Years of experience in the fishery |
|---|---|---|---|---|---|
| Sex | Pearson Correlation | 1 | 0.009 | 0.012 | 0.056 |
| | Sig. (2-tailed) | | 0.899 | 0.867 | 0.429 |
| Age Group | Pearson Correlation | 0.009 | 1 | .955** | .251** |
| | Sig. (2-tailed) | 0.899 | | 0.000 | 0.000 |
| Level of Education | Pearson Correlation | 0.012 | .955** | 1 | .236** |
| | Sig. (2-tailed) | 0.867 | 0.000 | | 0.001 |
| Years of experience in the fishery | Pearson Correlation | 0.056 | .251** | .236** | 1 |
| | Sig. (2-tailed) | 0.429 | 0.000 | 0.001 | |
| Sources and levels of income | Pearson Correlation | 0.095 | 0.075 | 0.059 | .205** |
| | Sig. (2-tailed) | 0.174 | 0.288 | 0.400 | 0.003 |
| Access to socio-technological infrastructure | Pearson Correlation | 0.010 | 0.001 | 0.006 | 0.062 |
| | Sig. (2-tailed) | 0.885 | 0.985 | 0.933 | 0.378 |
| Performance of the value chain | Pearson Correlation | -0.016 | .164* | .165* | 0.073 |
| | Sig. (2-tailed) | 0.820 | 0.019 | 0.018 | 0.296 |
| Non-discrimination | Pearson Correlation | -0.015 | -0.062 | -0.045 | 0.043 |
| | Sig. (2-tailed) | 0.828 | 0.377 | 0.523 | 0.538 |
| Access to information | Pearson Correlation | 0.009 | 0.114 | .138* | 0.054 |
| | Sig. (2-tailed) | 0.903 | 0.104 | 0.049 | 0.438 |
| Effective participation | Pearson Correlation | 0.090 | -0.011 | -0.039 | 0.049 |
| | Sig. (2-tailed) | 0.201 | 0.879 | 0.577 | 0.486 |
| Household food security | Pearson Correlation | 0.019 | -.150* | -0.135 | 0.003 |
| | Sig. (2-tailed) | 0.788 | 0.032 | 0.053 | 0.962 |
| Power relations | Pearson Correlation | -0.018 | 0.103 | 0.111 | -0.033 |
| | Sig. (2-tailed) | 0.797 | 0.141 | 0.114 | 0.643 |
| Capacity to process and store food | Pearson Correlation | -0.097 | -0.016 | -0.016 | 0.061 |
| | Sig. (2-tailed) | 0.166 | 0.825 | 0.824 | 0.387 |
| Diversity | Pearson Correlation | -0.025 | -0.053 | -0.019 | -0.052 |
| | Sig. (2-tailed) | 0.721 | 0.449 | 0.782 | 0.457 |
| Social self-organisation | Pearson Correlation | -0.066 | 0.064 | 0.076 | 0.009 |
| | Sig. (2-tailed) | 0.346 | 0.364 | 0.276 | 0.897 |
| Ancestral knowledge | Pearson Correlation | 0.060 | 0.117 | 0.114 | .165* |
| | Sig. (2-tailed) | 0.396 | 0.096 | 0.105 | 0.018 |
| Environmental benefits of the food system | Pearson Correlation | 0.071 | 0.058 | 0.069 | -0.044 |
| | Sig. (2-tailed) | 0.311 | 0.412 | 0.325 | 0.530 |
| Carbon footprint | Pearson Correlation | 0.034 | -0.023 | 0.020 | -0.070 |
| | Sig. (2-tailed) | 0.625 | 0.746 | 0.772 | 0.318 |
| Food system impacts on human health | Pearson Correlation | 0.069 | .185** | .150* | 0.126 |
| | Sig. (2-tailed) | 0.324 | 0.008 | 0.032 | 0.072 |
| **. Correlation is significant at the 0.01 level (2-tailed). | | | | | |
| *. Correlation is significant at the 0.05 level (2-tailed). | | | | | |

### *4.3.2 Testing for Internal Consistency*

Since the number of sampled respondents was 205, they made up a threshold to be subjected to exploratory factor analysis. Exploratory factor analysis is a statistical technique that is used to reduce data to a smaller set of summary variables and to explore the underlying theoretical structure of the phenomena. It is used to identify the structure of the relationship between the variable and the respondent. To conduct factor analysis, dummy variables derived from our

Likert Scale were used. In exploratory factor analysis, multivariate normality is not required, there should be correlation of at least 0.30 between the study variables and there should be no outliers in the data. The sample size should be more than 200 and it was assumed to be homogenous. Violation of this assumption increases the sample size as the number of variables increases and as such it was important to first test for the homogeneity of the variables under study. Reliability analysis was conducted to check the homogeneity between variables. Cronbach's alpha coefficient was used to determine the reliability and internal consistency of the 15-item Sustainability scale. The results indicate that the Sustainability Scale has good reliability and internal consistency (Cronbach's alpha coefficient = 0.669) as shown in Table *6* below.

Table 6: Cronbach's alpha for determining reliability of the data.

| **Intraclass Correlation Coefficient** | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Intraclass Correlation[b] | 95% Confidence Interval | | F Test with True Value 0 | | | |
| | | Lower Bound | Upper Bound | Value | df1 | df2 | Sig |
| Single Measures | .119[a] | 0.091 | 0.154 | 3.022 | 204 | 2856 | <0.001 |
| Average Measures | .669[c] | 0.599 | 0.732 | 3.022 | 204 | 2856 | <0.001 |

A further reliability analysis of all the fifteen perception measures (Table *7*) showed that the perception environmental benefits of the food system was dragging down the alpha. Excluding the variable would see the alpha rise to 0.704.

Table 7: Reliability index by excluding one variable from the model.

| **Excluded Variable** | **Cronbach's alpha** | **P-value** |
|---|---|---|
| Sources and levels of income | 0.643 | <0.001 |
| Access to socio-technological infrastructure | 0.648 | <0.001 |
| Performance of the value chain | 0.616 | <0.001 |
| Non-discrimination | 0.666 | <0.001 |
| Access to information | 0.638 | <0.001 |
| Effective participation | 0.667 | <0.001 |
| Household food security | 0.680 | <0.001 |
| Power relations | 0.614 | <0.001 |
| Capacity to process and store food | 0.651 | <0.001 |
| Diversity | 0.638 | <0.001 |
| Social self-organisation | 0.665 | <0.001 |
| Ancestral knowledge | 0.649 | <0.001 |
| Environmental benefits of the food system | 0.704 | <0.001 |
| Carbon footprint | 0.631 | <0.001 |
| Food system impacts on human health | 0.667 | <0.001 |

## 4.4 Inferential Statistics

### *4.4.1 Chi-Square Test of Homogeneity*

Because this study used categorical data, the data posed a challenge of making the power of respondents dissipate very fast. To make up for this limitation, we used Chi-square test to test for independence and ensure that any given perception response was independent of a respondent's sex (Table *8*). Our null hypothesis was that the perceptions on sustainability were independent of a respondent's sex thus:

$H_0$: Perceptions of sustainability are independent of sex.

$H_1$: Perceptions of sustainability are not independent of sex.

Table 8: Chi-square table

| | Perception | |
|---|---|---|
| | Not Sustainable | Sustainable |
| Female | 53 | 5 |
| Male | 123 | 24 |

The data based on our responses had a Chi-squared value of 2.03 and a p-value of 0.15. The p-value was more than the significance level of 0.05 thus we have no evidence to reject the null hypothesis. Consequently, we can conclude that that the perception of sustainability by a respondent was independent of their sex.

### *4.4.2 Analysis of Variance (ANOVA)*

Scores were summed for all statements (we reversed the score of a statement according to positive or negative nature of the statement) of each individual respondent. This enabled us get variance within the group and between groups. But to do this, we confirmed that the data met the basic assumptions for the application of parametric statistics. The analysis of variance was conducted between the fifteen sustainability perception scores for the score of between items. For the value of between items, analysis of variance was conducted on all the 205 respondents. In conducting the ANOVA, the grand mean score for all the fifteen perceptions that were under study was 2.32 as shown in Table *9* below. From this observation, we inferred that most perception scores were lying between the score of POOR and GOOD and thus we can conclude that the community perceived the Lake Turkana Fishery to perform quite low in terms of being a sustainable food system.

Table 9: ANOVA Table of sustainability perception scores

| | | **Sum of Squares** | **df** | **Mean Square** | **F** | **P** |
|---|---|---|---|---|---|---|
| **Between People** | | 507.917 | 204 | 2.490 | | |
| **Within People** | Between Items | 787.452 | 14 | 56.247 | 68.264 | <0.001 |
| | Residual | 2353.214 | 2856 | 0.824 | | |
| | Total | 3140.667 | 2870 | 1.094 | | |
| **Total** | | 3648.584 | 3074 | 1.187 | | |
| **Grand Mean = 2.32** | | | | | | |

| | Mean | Std. Deviation | Analysis N |
|---|---|---|---|
| Sources and levels of income | 1.59 | .804 | 205 |
| Access to socio-technological infrastructure | 2.05 | .951 | 205 |
| Performance of the value chain | 2.12 | 1.215 | 205 |
| Non-discrimination | 2.23 | .924 | 205 |
| Access to information | 2.90 | 1.190 | 205 |
| Effective participation | 1.86 | .750 | 205 |
| Household food security | 1.92 | .877 | 205 |
| Power relations | 2.47 | 1.297 | 205 |
| Capacity to process and store food | 2.08 | .842 | 205 |
| Diversity | 2.99 | 1.052 | 205 |
| Social self-organisation | 1.85 | .694 | 205 |
| Ancestral knowledge | 2.69 | .879 | 205 |
| Environmental benefits of the food system | 1.80 | .746 | 205 |
| Carbon footprint | 2.96 | 1.033 | 205 |
| Food system impacts on human health | 3.27 | 1.010 | 205 |

### *4.4.3 Ordinal Logistic Regression*

An ordered probit was conducted to examine whether perceptions could predict the sustainability of the food system. An analysis of standard residuals showed that the data contained no outliers (Std. Residual Min. = -1.291, Std. Residual Max. = 3.009). This indicates that the response values are in agreement with assumptions of normality (Weijters, Millet, & Cabooter, 2021). Independence of residual errors was confirmed with a Durbin-Watson test (d = 1.817) as shown in Table *10*. A rule of thumb is that DW test statistic values in the range of 1.5 to 2.5 for independent observations that take up a normal distribution (Garson, 2012). The variables measured (both perception measures and the external sociodemographic variables) significantly predicted the sustainability score of the food system, $F(2, 202) = 14.388$, $p < 0.05$ accounting for 62.5% of the variability in predicting the perception score of sustainability of the fishery with adjusted R-squared of 0.616. This is a moderately strong relationship (Wang, Jiang, & Liu, 2017). We used ordinal logistic regression to make predictions of the model because our dependent variable (the measure of sustainability) was ordinal and the independent response variables were either continuous, ordinal or categorical. The independent variables also did not have multicollinearity dependent. As with other types of regression, ordinal regression uses interactions between independent variables to predict the dependent variable.

Table 10: Ordinal Logistic Regression

**Model Summary[b]**

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate | Change Statistics | | | | | Durbin-Watson |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | R Square Change | F Change | df1 | df2 | Sig. F Change | |
| 1 | .353[a] | 0.625 | 0.616 | 0.314 | 0.625 | 14.388 | 2 | 202 | 0.000 | 1.817 |

a. Predictors: (Constant), Sociodemographic Factors, Perception Factors

b. Dependent Variable: Sustainability Score

**Variables in the Equation**

| | **B** | **S.E.** | **Wald** | **df** | **Sig.** | **Exp(B)** | **95% C.I.for EXP(B)** | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | Lower | Upper |
| Age | -0.196 | 0.280 | 0.493 | 1 | 0.048 | 0.822 | 0.475 | 1.421 |
| Level of Education | -0.562 | 0.299 | 3.526 | 1 | 0.060 | 0.570 | 0.317 | 1.025 |
| Years in fishery | -0.235 | 0.307 | 0.587 | 1 | 0.044 | 0.790 | 0.433 | 1.443 |
| Sources and levels of income | 0.023 | 0.321 | 0.005 | 1 | 0.094 | 1.024 | 0.545 | 1.922 |
| Access to tech infrastructure | 0.336 | 0.303 | 1.234 | 1 | 0.027 | 1.400 | 0.773 | 2.534 |
| Performance of the value chain | 0.584 | 0.273 | 4.560 | 1 | 0.033 | 1.793 | 1.049 | 3.065 |
| Non-discrimination | -0.181 | 0.324 | 0.311 | 1 | 0.058 | 0.835 | 0.443 | 1.574 |
| Access to information | 0.530 | 0.268 | 3.895 | 1 | 0.048 | 1.698 | 1.004 | 2.873 |
| Effective participation | 0.955 | 0.405 | 5.576 | 1 | 0.018 | 0.385 | 0.174 | 0.850 |
| Household food security | 0.747 | 0.309 | 5.833 | 1 | 0.016 | 2.111 | 1.151 | 3.872 |
| Power relations | 0.088 | 0.257 | 0.118 | 1 | 0.073 | 1.093 | 0.660 | 1.809 |
| Capacity to process & store food | -0.291 | 0.346 | 0.706 | 1 | 0.040 | 0.747 | 0.379 | 1.474 |
| Diversity | 0.099 | 0.260 | 0.146 | 1 | 0.072 | 1.104 | 0.664 | 1.837 |
| Social self-organisation | 0.356 | 0.401 | 0.788 | 1 | 0.037 | 1.427 | 0.651 | 3.131 |
| Ancestral knowledge | 0.053 | 0.340 | 0.024 | 1 | 0.087 | 1.054 | 0.541 | 2.054 |
| Environmental benefits | 0.476 | 0.414 | 1.320 | 1 | 0.025 | 1.610 | 0.715 | 3.628 |
| Carbon footprint | -0.488 | 0.298 | 2.691 | 1 | 0.101 | 0.630 | 0.509 | 0.721 |
| Impacts on human health | 0.910 | 0.339 | 7.201 | 1 | 0.007 | 2.485 | 1.278 | 4.831 |
| Constant | -9.271 | 2.420 | 14.677 | 1 | 0.000 | 0.000 | | |

a. Variable(s) entered on step 1: Age, Level of Education, Years in Business, Sources and levels of income, Access to socio-technological infrastructure, Performance of the value chain, Non-discrimination, Access to information, Effective participation, Household food security, Power relations, Capacity to process and store food, Diversity, Social self-organisation, Ancestral knowledge, Environmental benefits of the food system, Carbon footprint, Food system impacts on human health.

In the section below, the coefficient table above is used to develop the following ordinal logistic regression equation:

$$logit\ (y) = mx + c$$

$$logit\ (y) = -0.196x_1 - 0.562x_2 - 0.235x_3 + 0.023x_4 + 0.336x_5 + 0.584x_6 - 0.181x_7 + 0.53x_8 + 0.955x_9 + 0.747x_{10} + 0.88x_{11} - 0.291x_{12} + 0.099x_{13} + 0.356x_{14} + 0.053x_{15} + 0.476x_{16} - 0.488x_{17} + 0.91x_{18} - 9.271$$

Where $y$ = Sustainability score

$x_1$ = Age of respondent

$x_2$ = Education level

$x_3$ = Years in fishery

$x_4$ = Income level

$x_5$ = Access to socio-technological infrastructure

$x_6$ = Performance of the value chain

$x_7$ = Non-discrimination

$x_8$ = Access to information

$x_9$= Effective participation

$x_{10}$ = Food security

$x_{11}$ = Power relations

$x_{12}$ = Capacity to process and store food

$x_{13}$ = Diversity

$x_{14}$ = Social self-organisation

$x_{15}$ = Ancestral knowledge

$x_{16}$ = Environmental benefits

$x_{17}$ = Carbon footprint

$x_{18}$ = Impacts on human health

## 4.5 Results

### *4.5.1 Community perceptions on sustainability of the fishery*

The heat map in the stacked bar below (**Error! Reference source not found.**) shows the frequency distribution of perception scores for the different parameters that were being assessed. It shows that most perception scores on sustainability deemed the food system to either be poor or very poor. However, four perceptions were deemed as being good and this included access to information, ancestral knowledge, diversity and the food system's impact on the health of the local community. Subsequently, the perceptions on the environmental benefits derived from the food system, social self-organization of the fishing community, the food system's capacity to store and process food, performance of the value chain and access to socio-technological infrastructure had very low scores as shown by the heat map. The worst performance in terms of perception, however, was in regard to effective participation and contribution to household food security

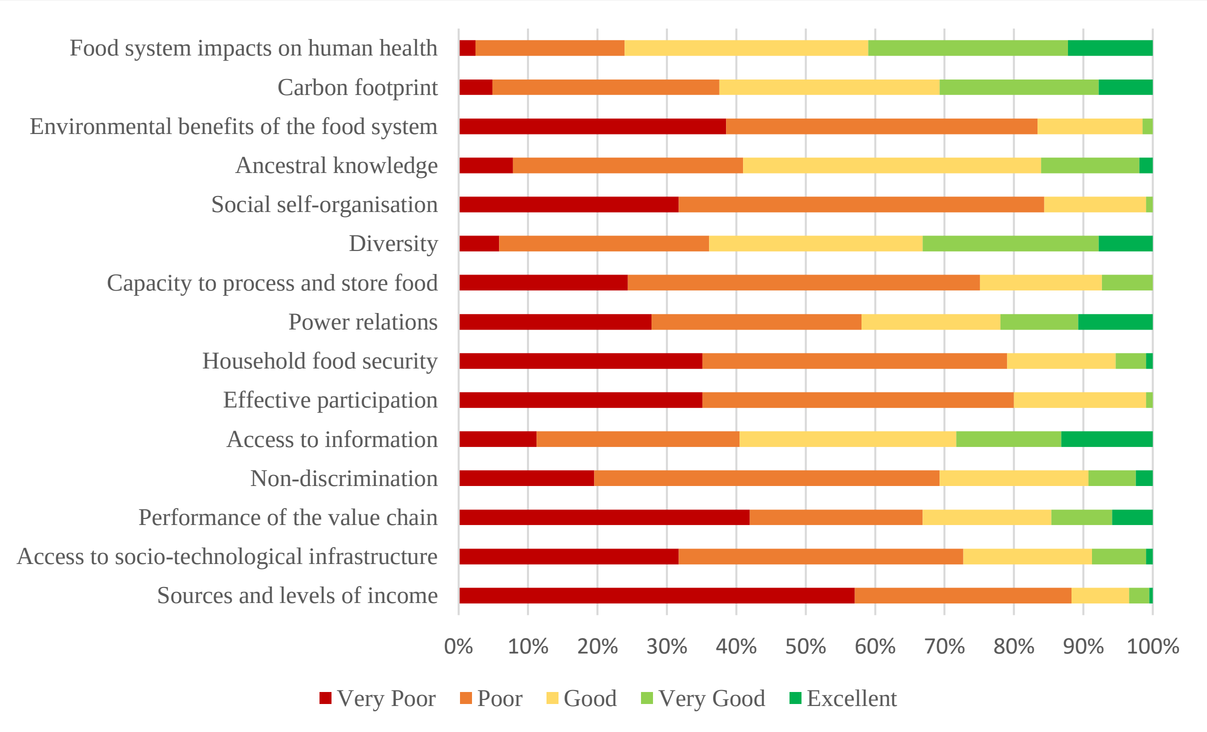


Figure 6: Frequency distribution of perception scores for different parameters from very poor to excellent.

All the three socio-demographic factors in the model (Age, Education level and Years in fishery) were found to have a negative relationship on the score of sustainability as shown in Table *10* of the ordinal logistic regression. The study found out that a unit increase in the length of years (10 years) in the fishery had the largest effect whereby it reduced the odds of the fishery being deemed sustainable by 0.43 with a 95% confidence level of odds of between 0.683 and -.05. On the other hand, a unit increase in the age bracket of a respondent was observed to reduce the odds of the fishery being deemed sustainable by 0.178, all other factors held constant. On the perception variables, the food system's impact on human health was deemed to have the largest odds for increasing a respondent's perception on the sustainability of the fishery. From the study, it could be inferred that a unit increase (on the Likert Scale) in perception of health benefits drawn from the food system would result to the fishery being deemed that it has increased in its sustainability 2.485 times. Generally, an increase in Likert scores of perceptions was associated with increased odds of the fishery being perceived as having increased in sustainability.


Figure 7: Sunburst of scores for the sustainability indicators that were studied.

The fishery had the highest perception score regarding its impact to human health (Mean = 3.27) as can be seen in Figure 7. The other parameter that performed well was diversity (Mean = 2.99) which essentially was ascertaining the diversity of fish species catches that were landed from the fishery. Overall, as can be seen from the sunburst graph, the key theme of the fishery's environmental performance was deemed to have the highest score with an average of 2.68. This key theme is made up of the sub-themes on a food system's and impact on human health (3.27), carbon footprint (Mean = 2.96) and environmental benefits (Mean = 1.8). The key theme with the lowest average perception score was on poverty and inequality. The food system was deemed to create very little in terms of employment and sources of income (Mean = 1.59), access to socio-technological infrastructure (Mean = 2.05) and the overall performance of the value chain (Mean = 2.12) making for an average of 1.92. The key theme of food security had an average of 2.16, right to food had 2.33 while socio-ecological resilience had 2.51. Of the fifteen parameters studied, only five had a score above 2.5 implying that the fishery was below average in its sustainability score (Figure *8*).

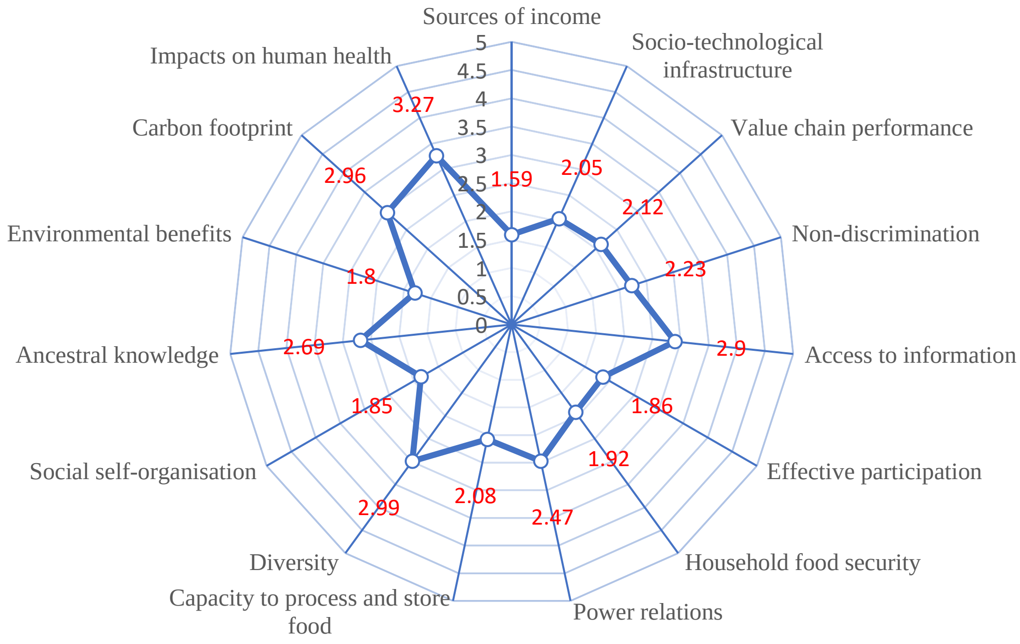


Figure 8: Spider graph showing scores for Sustainability Perception indicators for Lake Turkana.

### *4.5.2 Community-informed strategies for resilience building*

Most respondents (33%) felt that the biggest challenge facing the Lake Turkana Fishery was long and persistent droughts due to erratic rainfall patterns (Figure 9). Not only was this having an effect on water inflows into the lake, but it was contributing to increased dependency on the fishery since other alternative livelihoods were more severely hit by the drought. There was also the yet-to-be comprehensively studied rise in water level amidst the long drought. Overfishing of some species was identified as a challenge by 21% of respondents. Pollution was identified as a challenge by 10% of respondents. Pollution was mostly from agricultural and domestic effluents. Irrigation upstream was identified as a challenge by 6% of respondents, while damming upstream was identified as a challenge by only 4% of respondents.

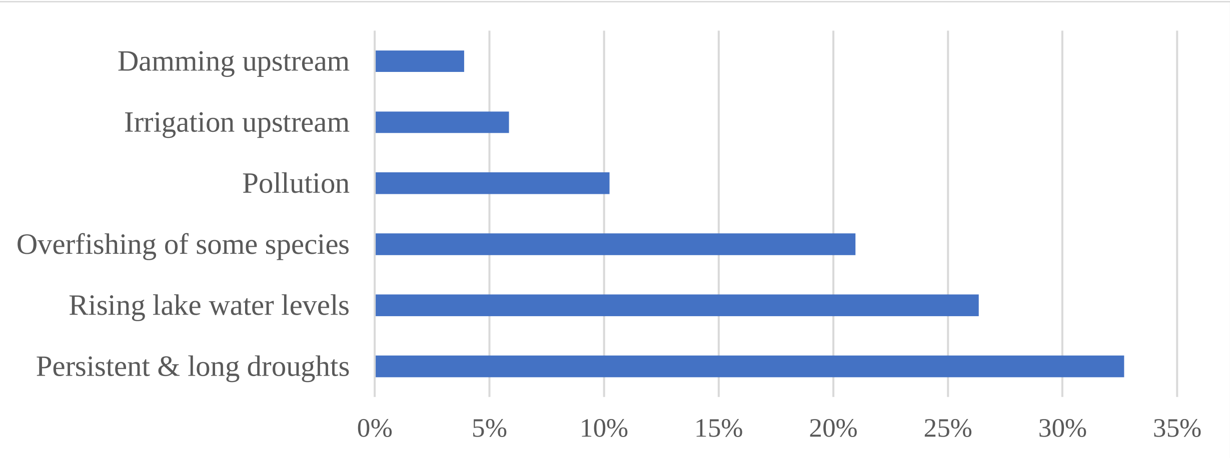


Figure 9: Challenges facing the Lake Turkana fishery according to the respondents.

In the face of these challenges, several community-informed solutions had been devised. The first one was the strengthening of operations of beach management units (BMUs). This was deemed to be the most preferred strategy to enhance the management of the fishery by 29% of the respondents. Sustainable fishing practices such as the use of appropriate and legal gear, landing of allowed catches and avoiding over-fishing in specific fishing sites was supported as the second most preferred community-informed strategy with 23% for enhancing sustainability of the fishery. The other community-informed strategies were use of new technologies utilizing solar energy to process and store fish (21%), the use of ancient knowledge in predicting weather and fish migration patterns (15%), promotion of equality and equity across genders and other marginalized groups (9%) and diversification of livelihoods into other income-generating activities such as irrigation and agro-pastoralism (3%) according to Figure *10* below.

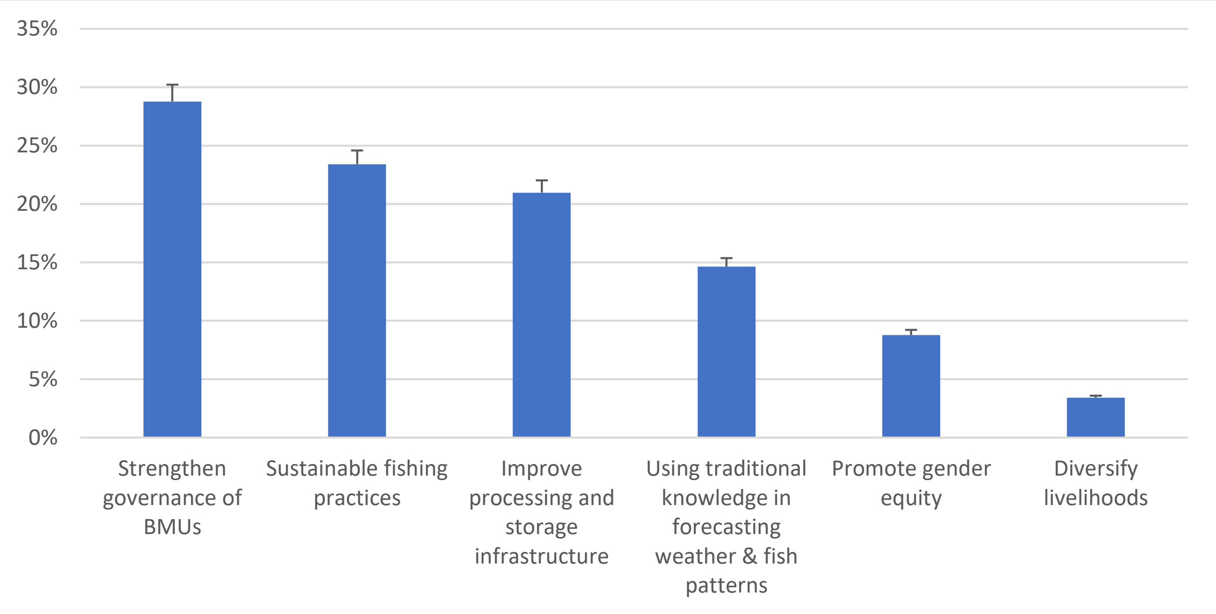


Figure 10: Community-informed resilience-building strategies to revitalize the Lake Turkana Fishery.

### *4.5.3 Gender issues and power relations*

For this study, anyone below the age of 35 was classified as belonging to the youth in line with the Kenyan Government's decision of who a youth is. Men dominated in gear ownership (82%), gear and input supplies (70%), transport (70%) and ownership of storage facilities (65%) as shown in Table *11* below. Women dominated in the marketing of fish (80%), processing of fish (67%) and post-harvest handling of fish on landing (58%). Youth only dominated in labour-intensive activities being offshore fishing (65%) and being casual labourers (57%).

Table 11: Table showing proportion of men, women and youth at various nodes of the fishery value chain.

| Activity | % Men | % Women | % Youth |
|---|---|---|---|
| Gear ownership | 82 | 11 | 7 |
| Gear and input suppliers | 70 | 21 | 9 |
| Transport | 70 | 12 | 18 |
| Storage facilities | 65 | 25 | 10 |
| Marketing | 15 | 80 | 5 |

| | | | |
|---|---|---|---|
| Processing | 25 | 67 | 8 |
| Post-harvest handling | 16 | 58 | 26 |
| Offshore fishing | 35 | 0 | 65 |
| Casual labourers | 33 | 10 | 57 |
| Onshore fishing | 42 | 19 | 39 |

In terms of which activities women most participated in, trading had 45% of all women in the fishery. 17% of them were selling fried fish, 11% sold fresh fish while the remaining 17% sold either sun-dried or salted or smoked fish (Figure *11*). 37% of the women participated in processing of fish with 12% doing salting, 11% doing sun-drying and 9% doing smoking. The remaining 17% of women were involved in production with almost half of these proportion offering services of transporting fish once it was landed.


Figure 11: Distribution of women in various activities in the Lake Turkana fishery.

# 5 DISCUSSION

## 5.1 Community perceptions on sustainability of the fishery

The grand mean score for all the fifteen sustainability perceptions that were under study was 2.32. Based on this, we can conclude that the community perceived the Lake Turkana Fishery to perform quite low in terms of being a sustainable food system. This corroborates research findings that describe inland fisheries to have been perceived as backward, informal and marginal economic activities (Platteau, 1989) and that their development is poorly integrated into national or local decision-making processes (Burgess et al., 2004; Sneddon & Fox, 2007). A low score on sustainability implies that there is need to improve the practices and policies of the fishery to ensure that it operates in a responsible and sustainable manner. This may involve implementing catch limits, species catch seasons, monitoring the use of fishing gear, protecting habitats, and working with the local community to ensure that they benefit from the fishery while also protecting the environment.

The fishery had the highest perception score regarding its impact to human health. The local communities heavily rely on the lake's fishery to meet their nutritional needs, particularly during periods of food shortages and drought. The other parameter that performed well was diversity, which essentially was ascertaining the diversity of fish species catches that were landed from the fishery. The Lake Turkana fishery is home to close to 60 documented fish species, 10 of which are endemic. The catch is dominated by Nile tilapia (*Oreochromis niloticus)*, Silverside (*Alestes baremose*) and Nile perch (*Lates niloticus*) accounting for 80% of total landings (C. H. Bironga et al., 2022). The fishery had its lowest score in regard to sources and levels of income that could be accrued through fishing and fishery-related economic activities.

The main factors hindering a robust fishery that could create decent jobs include limited infrastructure, lack of investment and a market with poor purchasing power. The fishery industry in Lake Turkana lacks adequate infrastructure such as proper and legal fishing gear, cold storage facilities, and transportation systems, which hinders the ability of fishermen to catch and transport fish to markets. The lack of investment has limited the ability of the industry to modernize and expand, which in turn limits the potential for job creation. Lastly, the remoteness of Lake Turkana, coupled with poor road infrastructure, limits access to markets beyond the region, reducing the potential demand for fish caught in the lake. This was in line with research, which indicated that the growing human population in the lake basin was heavily dependent on outside resources to survive rather than the fishery's sustainability (Wright, et. al., 2015). It is important to point out that changes in the environmental, economic, and sociocultural settings of the Lake Turkana region have been tightly interrelated, and that knowledge of the connections was needed to form development policy and governance issues targeted toward revitalizing the fishery.

While most of the scores had a positive relationship with perceptions of sustainability, perceptions on increase in carbon footprint, increase in non-discrimination of players (firms and individuals) in the fishery and increase in capacity to process and store food were being seen as having a negative impact on the fishery’s sustainability.

All the three sociodemographic factors in the model (Age, Education level and Years in fishery) were found to have a negative relationship on the score of sustainability. The study found that a unit increase in the length of years (10 years) in the fishery had the largest effect whereby it reduced the odds of the fishery being deemed sustainable by 0.43 with a 95% confidence level of odds of between 0.683 and -.05. On the other hand, a unit increase in the age bracket of a respondent was observed to reduce the odds of the fishery being deemed sustainable by 0.178, all other factors held constant. On the perception variables, the food system's impact on human health was deemed to have the largest odds for increasing a respondent's perception on the sustainability of the fishery. From the study, it could be inferred that a unit increase (on the Likert Scale) in perception of health benefits drawn from the food system would result to the fishery being deemed that it has increased in its sustainability 2.485 times.

## 5.2 Community-informed strategies for resilience building

The results of the survey show that the biggest challenges facing the fishery are persistent and long droughts and rising lake water levels. These challenges are likely linked to climate change and can have a significant impact on the fishery by affecting fish populations and their habitat. Persistent and long droughts can lead to decreased water levels, reduced water quality, and increased salinity, all of which can negatively affect fish populations. This can result in reduced catches and lower incomes for fishing communities. Rising lake water levels can also have a significant impact on the fishery. High water levels can cause flooding and erosion, which can damage fish habitat and reduce fish populations. This can also result in lower catches and incomes for fishing communities.

Overfishing of some species was identified as being one of the challenges. Overfishing can lead to depletion of fish stocks and can have long-term impacts on the fishery's sustainability. It is important to implement measures to prevent overfishing, such as fishing quotas and gear restrictions. Pollution was also identified as a challenge. Pollution from agricultural and industrial activities can negatively affect the water quality and fish populations in the fishery. It is important to implement measures to reduce pollution and promote sustainable practices. Irrigation upstream and damming upstream were also identified as part of the challenges. Both challenges can affect the water flow and nutrient levels in the fishery, which can negatively impact fish populations.

Building resilience in this fishery requires community-informed strategies that address the challenges facing the fishery while taking into account the needs and priorities of the local communities. Since the community is one of the most underserved and marginalized, there is need to encourage sustainable fishing practices: Overfishing is a major threat to the fishery's sustainability. To address this, community members should be educated about the importance of sustainable fishing practices such as using appropriate gear, implementing fishing quotas, and avoiding the catch of immature fish. This can be done through community meetings and workshops, and by working with local fishing cooperatives to promote responsible fishing. However, it is worth noting that over-reliance on fishing for livelihoods can lead to depletion of fish stocks and vulnerability to external shocks. Supporting and promoting alternative livelihoods, such as agroforestry, ecotourism, and handicrafts can help reduce dependence on fishing while providing economic opportunities for the community. These alternatives should be developed in consultation with the community members to ensure they are relevant and sustainable. There is also a need to strengthen governance of the BMUs. Studies have shown that weak governance can result in overfishing, resource depletion, and unsustainable practices (Ateweberhan et al., 2018; Masai, Mbithi, & Mwangi, 2005; Tanner et al., 2014). Promoting community-based governance structures that are transparent, accountable, and participatory can help to ensure that the needs and priorities of the community are taken into account, and that decisions are made in the best interest of the fishery and the community as a whole.

These strategies should be developed and implemented in collaboration with the local community, taking into account their knowledge, needs, and priorities. By building resilience in the fishery, we can help ensure that it remains a sustainable resource for future generations.

## 5.3 Gender issues and power relations

People living in and around the Lake Turkana fishery are some of the poorest in Kenya due to many factors restricting their abilities to engage in activities to secure food and income. This study sought to stratify areas where each gender and or special group stood out. Men dominated in gear ownership, gear and input supplies, transport and ownership of storage facilities. Women dominated in the marketing of fish, processing of fish and post-harvest handling of fish. Youth only dominated in labor-intensive activities - offshore fishing and being casual laborers.

Women, and in particular resident women, were especially found to be constrained given certain gender norms and power relations that hamper them from accessing and adequately benefiting from the fishery. Women who live in the fishery generally rely on other, less lucrative methods to support themselves. Non-resident women fish sellers have distinct relationships with fishers since they have more money, knowledge, and confidence, yet their negotiations might still place them at a disadvantage in terms of their personal and financial situation while trying to gain access to fish. The challenges that women generally face were in the production nodes. This included lack of capital, low or no access to credit facilities, cultural and social norms and taboos, and their reproductive role in society. Men didn’t feature prominently in the processing node. This was mainly attributed to their lack of or generally low skills to match desired product quality. The other one was that learning the art of different processing of fish required a lot of time and patience to learn and master. The youth were mostly relegated to labor-intensive activities. This was attributed to amongst others lack of capital and the lack of market networks and skills.

Fishing activities are typically conducted in groups, which fosters a sense of community and promotes cooperation and mutual support among community members. As part of the community’s few resources, the fishery plays an essential role in promoting social cohesion and community development. Thus, there is need to involve women, youth and other marginalized groups more in the management of the fishery. This can be achieved through education and training, promoting equitable participation in decision-making, and providing access to resources such as credit and equipment.

## 5.4 Generalizability of Results

Kenya's Rift Valley lakes have similar terrain and are inhabited by communities that are largely agro-pastoralists. Thus, their practising of fishing is mostly an after-thought alternative. As such, results from this study can be generalized on the other lakes. With the exception of Lake Naivasha which is found in the booming agricultural town of Naivasha, the rest are inhabited by communities whose incomes are very low. It is important to consider several factors when determining the generalizability of research results. While the similarity in terrain and community practices between Kenya's Rift Valley lakes suggests that the results of a study conducted in one lake may be applicable to the others, it is also important to consider the specific context and characteristics of each lake and its community.

For example, the fact that Lake Naivasha is located in a booming agricultural town with potentially different economic conditions and practices compared to other lakes' communities may affect the applicability of the study's results to this particular lake. Additionally, other factors such as sample size, research design, and statistical analysis must be considered when determining the generalizability of research results. Therefore, while the similarity in terrain and community practices between Kenya's Rift Valley lakes may suggest some generalizability of research results, it is important to carefully consider the specific context and characteristics of each lake and its community before making any broad conclusions.

# 6 CONCLUSION AND RECOMMENDATIONS

## 6.1 Conclusions

Based on the findings of the study, it can be concluded that the sustainability of the Lake Turkana fishery is currently perceived as low. The negative relationship between sociodemographic factors such as age, education level, and years in the fishery and the score of sustainability indicates that the more experienced the fishers are, the less likely they are to adopt sustainable practices. This could be because they have been using traditional and unsustainable fishing methods for a long time, which has led to overfishing in specific areas and landing of juveniles resulting to depletion of fish stocks. The study also showed that the community was embracing the use of traditional and adaptive knowledge to be resilient in the face of climate change threatening their livelihoods. Gender relations were observed to follow strict boundaries that were informed by gender roles, age and socioeconomic factors.

Furthermore, the negative impact of perceptions on the increase in carbon footprint, non-discrimination of players in the fishery, and lack of capacity to process and store food on the fishery's sustainability suggests that there are significant challenges that need to be addressed to improve the fishery's sustainability. Use of better facilities in fishing such as boats and processors should ideally result in better fish handling and sustainable fishing. However, the positive relationship between perceptions of the food system's impact on human health and the fishery's sustainability indicates that there is potential to improve the fishery's sustainability by promoting sustainable fishing practices that protect human health and the environment. This is in line with the Government of Kenya’s efforts to realize food and nutritional security in line with the Sustainable Development Goals (SDGs). A sustainable Lake Turkana Fishery will amongst others lead to alleviation of hunger (SDG 2), good health of the community (SDG 3) and creation of more and better sources of income (SDG 8), a well exploited and thriving fish ecosystem (SDG 14).

Overall, the results of this study suggest that significant efforts are needed to improve the sustainability of the Lake Turkana fishery, including implementing sustainable fishing practices, improving the value chain, enhancing monitoring and enforcement, and investing in research and data collection.

## 6.2 Recommendations

Using the FOODSAF, areas for recommending intervention are usually those that have low scores. The Lake Turkana Fishery performed dismally low for most of the factors of sustainability. To improve the fishery in Lake Turkana and attain sustainability, the following recommendations can be made based on this study:

1. Development of a comprehensive management plan: The fishery needs a comprehensive management plan that considers the ecological, social, and economic factors affecting it. The plan should include regulations for fishing gear, catch limits, and closed seasons to prevent overfishing.
2. Encourage community-based management: The local community should be encouraged to exploit the fishery in a sustainable way. This can be achieved by involving them in decision-making processes and providing them with the necessary resources and skills for proper harvesting practices, post-harvest handling and processing, establishing fishing practices that conserve the fishery through demarcated fish breeding sites and breeding zones.
3. Encourage sustainable fishing practices: Fishers should be encouraged to use sustainable fishing practices, such as using selective fishing gear and avoiding fishing during the breeding season.
4. Improve the value chain: Efforts should be made to improve the value chain for fish products. This can be achieved by providing training on post-harvest handling, processing, and marketing of fish products.
5. Promote alternative livelihoods: Alternative livelihoods should be promoted to reduce fishing pressure on the lake. This can be achieved by providing training and resources for alternative income-generating activities such as ecotourism or agriculture.
6. Enhance monitoring and enforcement: Monitoring and enforcement of fishing regulations should be enhanced to ensure compliance and prevent illegal fishing activities.
7. Invest in research and data collection: Research and data collection should be invested in to better understand the fishery and to inform management decisions. Data collection continues to be a big challenge, and this makes management of the Lake Turkana fishery an afterthought that is never prioritized in budgeting.

While the study was based on community perceptions and experiences, there is need to conduct stock assessments and frame surveys to get a clear and realistic picture of the status of the fishery. It is important to conduct stock assessments and surveys in order to gather accurate and reliable information on the status of the fishery. This information can then be used to develop effective management strategies and policies. By implementing these recommendations, the fishery in Lake Turkana can be improved and moved towards sustainability.

## 6.3 Areas for further study

The study was limited to perceptions and as such did not involve measurements that are not subject to personal biases. The study was also limited to respondents who live within fishing villages and who have had significant interactions with the fishery at different levels either as consumers or producers. A bigger study engaging the entire community including those not involved and or never involved in the fishery would help shed more light on what the community perceives of the fishery. For ecological measurements, it is important to collect data on the ecological impact of the fishery, such as changes in fish populations, ecosystem health, and biodiversity. These measurements can help assess the sustainability of the fishery and identify potential risks to the system. There is also need to understand the economic viability of the fishery by assessing its long-term sustainability. This will, amongst other things, involve analyzing the costs and benefits of the fishery, including the income generated by the fishery and the costs associated with managing and maintaining it. It is also important to understand how the fishery impacts the social fabric of the community, including the social and cultural values attached to the fishery, the distribution of benefits and costs, and the impacts on the well-being of community members.

Another key aspect of sustainability that was not well probed by this study is on governance of the fishery. There is need to study governance structures and decision-making processes in order to understand how the fishery is managed and regulated. This involves analyzing the policies, institutions, and actors involved in the fishery, and assessing their effectiveness in achieving sustainability goals. Lastly, a study on long-term monitoring is needed since sustainable food systems require ongoing monitoring to ensure that they remain sustainable over time. This involves collecting data on the ecological, economic, and social dimensions of the fishery on a regular basis and using this information to adapt management practices as needed.

Overall, a comprehensive and interdisciplinary approach is needed to study the sustainability of the fishery food system, considering its ecological, economic, social, and governance dimensions.

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## APPENDIX I: INTRODUCTION LETTER

You have been requested to participate in this focus group discussion and answer this questionnaire based on discussions we will have as part of a research project conducted by me, **Chadwick Bironga Henry**, a researcher with the Kenya Marine and Fisheries Research Institute and a fellow under the GRO Fisheries Training Programme. The research project is called **Using Community Perceptions to Assess the Sustainability of the Lake Turkana Fishery Food System**. The study is designed to collect the community’s perceptions on the performance of the Lake Turkana Fishery food system to deduce areas of strength and weaknesses and to determine if the stakeholders of the Lake Turkana fishery appraise it as a sustainable food system. The study will also seek to enumerate community-informed strategies for resilience building of the Lake Turkana Fishery and to assess gender issues and power relations in the various value chain nodes of the Lake Turkana Fishery.

You are being requested to participate in this because as a member of a Beach Management Unit within the Lake Turkana Fishery, you are an important stakeholder with hands-on information that will be important for this study. Your responses in this interview are entirely voluntary, and you may refuse to answer any or all of the questions in this interview that you may find not necessary or offending. By agreeing to participate in the interview, you affirm that you give your consent for me, to record this interview and to use your answers in my research. All responses will be anonymized, and there will be no way to trace your responses back to you. If you have any questions about this research before or after you complete the interview, you can direct them to me for clarification.

With kind regards,

Chadwick Bironga

APPENDIX II: QUESTIONNAIRE

**USING COMMUNITY PERCEPTIONS TO ASSESS THE SUSTAINABILITY OF THE LAKE TURKANA FISHERY FOOD SYSTEM**

Geographical & Identification

Date (yyyy-mm-dd) ______________________________

To which zone of the Lake Turkana Fishery do you belong?

- ☐ Zone 1 (Northern BMUs)
- ☐ Zone 2 (Kalokol BMUs)
- ☐ Zone 3 (Longech BMUs)
- ☐ Zone 4 (Southern BMUs)

Record your current location:

latitude (x.y

______________________

longitude (x.y

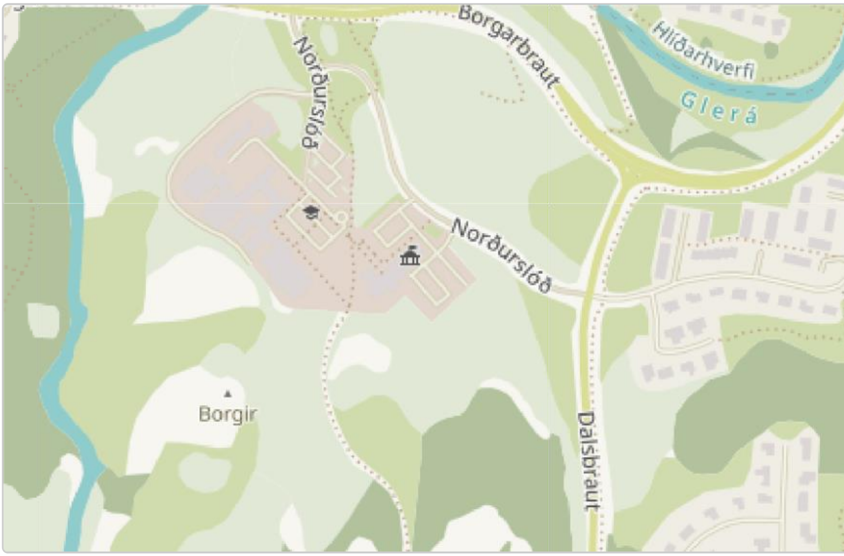
______________________

altitude

______________________

accuracy

______________________




Respondent Serial Number ______________________________

Demographic Data

Sex of the respondent

- ○ Male
- ○ Female

Age of the Respondent

- ○ 18 to 29 years
- ○ 30 to 39 years
- ○ 40 to 49 years
- ○ 50 and above years

Level of education of the Respondent

- ○ No formal education
- ○ Lower primary
- ○ Upper primary
- ○ Secondary
- ○ Tertiary (Technical education)
- ○ Undergraduate
- ○ Postgraduate

Years in the fishery

- ○ Less than 1 year
- ○ 1 to 5 years
- ○ 6 to 10 years
- ○ 11 - 20 years
- ○ 21 to 30 years
- ○ Above 30 years

**Theme 1: Poverty and Inequality**

1. In terms of employment creation, how would you rate the fishery's ability to create sources of income?

☐ Very Poor

☐ Poor

☐ Good

☐ Very Good

☐ Excellent

2. How would you rank your access to socio-technological infrastructure in the fishery?

☐ Very Poor

☐ Poor

☐ Good

☐ Very Good

☐ Excellent

3. How would you rank performance of the fishery's value chain in terms of offering competitive advantage in comparison to other fisheries?

☐ Very Poor

☐ Poor

☐ Good

☐ Very Good

☐ Excellent

**Theme 2: Right to Food**

4. How would you rate the ability of fishery players to access market information as regards various aspects of the fishery?

☐ Very Poor

☐ Poor

☐ Good

☐ Very Good

☐ Excellent

5. How would you rank the openness to exploit the fishery by any willing and able participant (non-discrimination)

☐ Very Poor

☐ Poor

☐ Good

☐ Very Good

☐ Excellent

6. How effective are all players regardless of their differences in making the food system productive?

☐ Very Poor

☐ Poor

☐ Good

☐ Very Good

☐ Excellent

**Theme 3: Food Security**

7. How would you rank your household's food security status?

☐ Very Poor

☐ Poor

☐ Good

☐ Very Good

☐ Excellent

8. How would you rank power relations in regards to making food consumption decisions in terms of age, sex and education?

☐ Very Poor

☐ Poor

☐ Good

☐ Very Good

☐ Excellent

9. How would you rank the fishery in terms of its capacity to process and store food?

☐ Very Poor

☐ Poor

☐ Good

☐ Very Good

☐ Excellent

**Theme 4: Socio-ecological resilience**

10. How does the fishery fair in terms of diversity in terms of fish products available for consumption?

☐ Very Poor

☐ Poor

☐ Good

☐ Very Good

☐ Excellent

11. How would you rate the social self-organisation of players in this Fishery?

☐ Very Poor

☐ Poor

☐ Good

☐ Very Good

☐ Excellent

12. How would you rate the use of Indigenous Knowledge in increasing the productive efficiency of this fishery?

☐ Very Poor

☐ Poor

☐ Good

☐ Very Good

☐ Excellent

**Theme 5: Environmental performance**

13. In terms of benefits to the General Environment, what do you think of the contribution of this fishery?

☐ Very Low

☐ Low

☐ Average

☐ High

☐ Excessive

14. In terms of Carbon Footprint, what do you think of the contribution from this fishery in all value chain nodes?

☐ Very Low

☐ Low

☐ Average

☐ High

☐ Excessive

15. What do you think of the food system impacts of this fishery on the human health of direct dependents?

☐ Very Low

☐ Low

☐ Average

☐ High

☐ Excessive

16. What are the current climate change and anthropogenic threats to the fishery, and how have they impacted the local community's livelihoods?

17. Who are the key stakeholders in the fishery, and what are their roles and responsibilities in building resilience?

18. What are the community's existing coping mechanisms and adaptive strategies for dealing with climate change and other threats to the fishery?

19. How can local knowledge and expertise be integrated with scientific research to develop effective resilience-building strategies for the fishery?

20. What are the roles and responsibilities of women and youth in the different nodes of the Lake Turkana fishery value chain, and how do they differ?

21. How do gender norms and expectations influence access to and control over resources, such as fishing gear, boats, and credit, in the fishery?

22. What are the specific challenges faced by women and men in the fishery value chain, and how do these challenges vary across different nodes?

23. How do power dynamics and hierarchies within the fishery value chain affect women's and men's ability to negotiate prices, access markets, and make decisions?

24. What are the barriers that prevent women from participating in decision-making processes related to the fishery, and how can they be overcome?

25. How do women's and men's different levels of access to education, information, and training affect their ability to participate in the fishery value chain and to benefit from it?

26. What are the policy and institutional changes needed to ensure that gender issues are adequately addressed in the governance and management of the Lake Turkana fishery value chain?

Thank you for taking your time to complete this questionnaire. We highly appreciate it and value the information that you have provided.