

The role of fish in food security: multidisciplinary approaches to support Kenyan fishing communities around Lake Victoria

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For a nourished world, in which food inspires joy.

Declaration

I hereby declare that this thesis has been composed entirely by myself. The work presented in this thesis has not previously been submitted for any other degree or qualification. The nature and extent of my work carried out by, or in conjunction with others, has been specifically acknowledged by reference.

Alexandra Pounds

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Abstract

Improving food security is key to achieving the United Nation's Sustainable Development Goal 'Zero Hunger', particularly relevant in Sub-Saharan Africa (SSA)'s inland fishing communities. This thesis aimed to examine the role of fish in food security from multiple disciplinary perspectives to generate a wholistic appreciation. The research aimed to identify the cultural, nutritional, and economic value of fish in local diets using qualitative and quantitative methods. Methods included interviews, focus groups, household surveys, intrahousehold surveys, and food intake measurements. Additionally, Oral Histories methods with Elders and PhotoVoice methods with youths were employed to include older people and youths' experiences and perspectives on food security, informed by participatory research frameworks. The study area was on the Kenyan shores of Lake Victoria, chosen for being the largest lake in SSA, its complex political and ecological history, and its large littoral (lakeshore) population who depend on its resource.

This thesis found that multiple methods indeed enhance our understanding of food security. While characterised by monotonous diets with an overreliance on nutrient-poor foods and poor dietary diversity, nutrient intake measurements showed adequate nutrient intake of commonly deficient micronutrients. These results were all-embracing, with little differences between gender or generation. Food security has worsened in the last 20 to 30 years, attributed to food commoditisation. Subsistence production was scarce, and people relied on income for food purchasing. As a result, the poor were a nutritionally vulnerable demographic. Differences in food security existed between economic classes, mainly concerning choice, food agency, and experiences of food security. The poor heavily relied on omena (*Rastrineobola argentea*), which is a small, low monetary value, but micronutrient-rich pelagic fish with disproportionate importance in worse-off diets. However, wellbeing is not limited to nutritional intake: poor people had negative subjective experiences of food security caused by omena overconsumption, its shameful association with poverty, and a lack of food agency. While the poor desired less omena, the rich desired more omena as it was increasingly recognized as a nutritionally dense food. Omena appears to be on the cusp of gentrification.

The indirect role of fish in food security was most obvious through livelihood generation. This population was on the precipice of a livelihood transition: while still dependent on fishery livelihoods that are decreasingly sufficient due to overfishing, people were beginning to look and aspire to other industries. Due to the need for cash for food purchasing, people increasingly sought out and respected jobs that had reliable income sources. This need for household income has increased the need for women to work outside of the homestead. But despite the increased need for income for food provisioning, gender inequalities persisted and were limiting women's income-earning potential. While the community continued to rely on fisheries for economic activity, women were marginalised in the fish value chain, limited to processing jobs. They were largely limited to omena processing and marginalised from higher-value activities. Omena was not valuable enough to trade for other

equally valuable food. Yet, the omena-drying business directly supported household food security because omena was retained for household consumption. This was not true for participation in fishing, which was not correlated with any food security indicators.

Finally, this research discovered that locals viewed emergent aquaculture as a ‘modern’ version of fishing, rather than a distinct or competing industry. They identified several benefits to large-scale fish farms, mainly concerning employment opportunities and auxiliary economic benefits. Emergent aquaculture was characterised by large-scale tilapia cage farms driven by international investment; however, local entrepreneurs felt inspired to begin smaller-scale pond farming. While aquaculture supported food security indirectly through employment, its direct effects on local fish provisioning was limited, as most locals purchased wild fish that were sourced from the lake. Farmed fish were only affordable by wealthier people around the lake and thus was not directly supporting the local food security of the poor. The role of aquaculture in food security was primarily through economic pathways rather than direct provisioning of food.

In summary, this thesis has identified the need for targeted interventions to advance the food security of Kenyan littoral communities around Lake Victoria. Gendered approaches within the fisheries and aquaculture value-chains are required for household-level improvements in both income and food security. Furthermore, this thesis calls for more holistic research concerning food security in other littoral communities in SSA. These types of studies and interventions are critical in achieving our global quest for ‘zero hunger’ for Lake Victoria’s littoral communities in Kenya.

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Abbreviations

ASF	Animal Source Food
BDI	Burundi
BMU	Beach Management Units
CPUE	Catch per unit effort
DRC	Democratic Republic of Congo
EU	Europe
FIES	Food Insecurity Experience Scale
HDDS	Household Dietary Diversity Score
HIV	Human immunodeficiency virus
KEN	Kenya
KSh	Kenyan Shillings
LVFO	Lake Victoria Fisheries Organisation
MDD-W	Minimum Dietary Diversity Score for Women
SSA	Sub-Saharan Africa
TZA	Tanzania
UGA	Uganda
ZAR	Zaire

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Chapter 1: Introduction

Improving food security is key to achieving the United Nation's Sustainable Development Goal 'Zero Hunger'. Addressing food insecurities in Sub-Saharan Africa (SSA) is particularly salient considering its nations have some of the highest rates of food insecurity globally (Muringai et al., 2022). The United Nations World Food Summit described food security as “the right of everyone to have access to safe and nutritious food, consistent with the right to adequate food and the fundamental right of everyone to be free from hunger” (Shaw, 2007, pg 351). In SSA, the proportion of the population experiencing food insecurity has increased from 51% in 2014 to 70% in 2021, mainly due to exponential growth in population with insufficient increase in agricultural outputs (Wudil et al., 2022). Malnutrition in SSA is responsible for high stunting rates (30.7% in 2020), anaemia in 40% of all women, and 750,000 deaths attributable to poor dietary composition annually (Springmann et al., 2021). An estimated 39% of household are food insecure in terms of food access and 49% of households had micronutrient deficiencies during lean periods (Fraval et al., 2019). Malnutrition in SSA is directly related to household food insecurity (Drammeh et al., 2019). SSA's food insecurity is linked to poverty: approximately 57% and 33% of the population live in poverty and extreme poverty, respectively (Springmann et al., 2021). Poverty, malnutrition, and high rates of infectious diseases, such as HIV/AIDS, present a significant challenge for Africans (Owino, 2019).

In the context of a malnourished region, many Sub-Saharan Africans rely on freshwater fish for nutrients and livelihoods, with certain populations particularly dependent (Fluet-Chouinard et al., 2018; Funge-Smith & Bennett, 2019; Temesgen et al., 2019). Small pelagic fish are particularly critical for lower- and middle-income countries due to their affordability, accessibility, and nutrition density (O'Meara et al., 2011; Robinson et al., 2022; Mills et al., 2023). Freshwater fish can supply an array of commonly deficient micronutrients, including calcium, iron, zinc, and vitamin A, as well as unique fatty acids EPA and DHA that are only found in fish (Kawarazuka & Béné, 2010; Troell et al., 2019). Freshwater and marine fish contribute 19% of animal source protein in Africa, yet paradoxically, Africa's fish consumption is the lowest globally at 10.8 kg annually, compared to a global average of 20.5kg annually, and has a large regional fish deficit (Chan et al., 2019; FAO, 2022). Broader food purchasing in markets is supported by income from the estimated 12.3 million people in the African fish value chain (FAO, 2022). Thus, understanding regional fish production and supply is critical for supporting fish consumption, value-chain livelihoods, and food security.

In response to fish supply deficit, production from regional fisheries and aquaculture have intensified. Freshwater 'food fish' are increasingly produced from both aquaculture and fisheries globally, as well as in Sub-Saharan Africa (Little et al., 2016; FAO, 2022). For this publication, 'food fish' are defined as aquatic animal species produced or harvested to supply human food value chains, for direct consumption or as feed for livestock and aquaculture. In Sub-Saharan Africa, food fish production from both inland capture fisheries and aquaculture has grown exponentially since the

1950s (FAO, 2022). The increased catch from inland fisheries has been supplied by small pelagic fish, which now represent approximately three-quarters of Africa's total inland fisheries catch (Kolding et al., 2019). These fishes are consumed by low-income populations or are included as aqua-feed ingredients for aquaculture (Kolding et al., 2019). Aquaculture production systems across SSA vary widely, ranging from smallholder production, which was introduced in the 1950s by colonists to support food production (Brummett et al., 2008), and more recently, large-scale production in Nigeria, Uganda, Ghana, and elsewhere (Adeleke et al., 2020). Between them, a variety of production models exist (Brummett et al., 2008) and an updated review of the state of aquaculture in SSA is warranted.

While aquaculture and fisheries production are often framed as a binary in global discussions (Pounds et al., 2023), food fish are produced from a continuum of aquaculture and fisheries, with an array of interactions and overlaps in their value chains (Islam, 2007; Amilhat et al., 2009; Little et al., 2016; Tezzo et al., 2021). In Zambia, for example, some rural smallholder ponds produce stocked and self-recruiting species, which swim into the ponds to breed and recruit in the system, supplying the producers' households with fish during the fishing bans (Kaminski et al., 2022). Thus, development policies for fisheries and aquaculture should complement sustainable and nutrition-sensitive solutions, particularly for the Global South, where food insecurities are most severe (Belton & Thilsted, 2014; Thilsted et al., 2016). Yet, research often takes a siloed approach to understanding the role of fish in food security of these fishing communities. Opportunities remain to explore the nutritional relevance of the fish in communities' livelihoods and broader diets, as well as its value within local food culture.

Thus, this thesis aims to examine the role of fish in food security from multiple disciplinary perspectives to generate a wholistic appreciation. The research aimed to identify the cultural, nutritional, and economic value of fish in local diets using qualitative and quantitative methods. The study area is on the Kenyan shores of Lake Victoria, chosen for being the largest lake in SSA, its complex political and ecological history, and its large littoral population who depend on its resource. This research first provided an updated description of the state of food security and the food system in the study area. With that context in mind, the thesis then progressed to examining the mechanisms behind which fish contribute to food security. We did this at various levels – between households and family members – to examine livelihood-based, gendered, and generational differences.

This thesis is structured as follows: it begins with two literature reviews: the first a systematic review of literature about the role of fish in food security in SSA, and a second in which articles pertaining to Lake Victoria, its fisheries, and its littoral communities are reviewed for a complete understanding of research on this thesis' study area. This is followed by a methods chapter with subsections dedicated to each of the four observational studies. This methods chapter includes a summary of the four datasets obtained and how they were used in the ensuing four results and

discussion chapters. The first results and discussion chapter reviewed the qualitative dataset, including an updated description of the food system and local fishery value-chain. Then, results from a household survey are presented and discussed, comparing food security between households in connection with their livelihoods. At that point, the thesis will take you within the household to examine differences in food security between family members. This is followed by a deeper dive into micronutrient intakes at the individual level, comparing commonly deficient micronutrients between family members. These four results and discussion chapters are followed by a broader discussion chapter, scrutinising and contextualising the four experiments regarding each other.

Chapter 2: “Understanding the role of freshwater fish from across the aquaculture-fisheries continuum in Sub-Saharan African food security – a systematic review”

The literature for fisheries and aquaculture have often been siloed and relatively uninformed of the other, and both are separated from broader food security discussions (Stetkiewicz et al., 2022). Fish production (i.e., fishing and fish farming), provisioning (i.e., how consumers acquire fish, either through purchasing in markets, being gifted from a neighbour, etc), and consumption (i.e., preparation and intake) are crucial to food systems research yet consistently understudied, considering the importance of fish to the food security of vulnerable communities (Béné et al., 2015; Tezzo et al., 2021). A prior scoping review examined literature regarding provisioning and consumption in SSA (de Bruyn et al., 2021), no systematic reviews have included the production element of food fish systems research. Thus, this scoping review aimed to examine research combining all three elements of aquatic food within food systems in SSA. I asked the following research questions:

- What role does fish play in food security in SSA?
- How do SSA’s food security researchers frame food fish provisioning from fisheries and aquaculture – as a dichotomy or a continuum?
- To what extent are food security development and policy recommendations from the literature based on an understanding of the food fish production continuum?

The review aims to describe the scope of the existing literature on the role of fish in food security in SSA, considering both aquaculture and fisheries production (and their integration), provisioning, and consumption. This article details the methods and results of the systematic scoping review, followed by a discussion and recommendations on future research requirements.

2.1 Methods

This scoping review identifies and evaluates the breadth of literature on the role of freshwater fish from across the fisheries-aquaculture continuum in providing nutrients to Sub-Saharan Africans. This review (1) identified, (2) compiled, (3) coded and categorised, and (4) summarised literature that investigated the role of fish in food security in SSA. Methods were designed based on the PRISMA checklist (Page et al., 2020) and methods described by Arksey and O’Malley (2005), Levac et al. (2010), Pham et al. (2014), Bene et al. (2016) and Budhathoki et al. (2022). Coding methods were based on Saldaña (2018).

(1) Identifying: This primary phase used two search strategies in online search engines to identify all literature that (1) mentioned both freshwater fisheries and aquaculture, (2) had fish consumption as a central component to the analysis and discussion, and (3) had a study area focus on Sub-Saharan

Africa. The first search strategy compiled all literature relating to freshwater aquaculture and fisheries in Sub-Saharan Africa. The second search strategy identified all literature relating to fish consumption in Sub-Saharan Africa.

The first search was conducted on 13th January 2023 using the electronic databases Web of Science and Scopus. The search was limited to articles between 1990 and 2023. The string of search terms aimed to collect all literature concerning freshwater aquaculture and fisheries in Sub-Saharan Africa: *(fisheries OR aquaculture) AND freshwater NOT marine AND ("Sub-Saharan Africa" OR "Sub-Sahara Africa" OR Angola OR Burundi OR "Central African Republic" OR Chad OR Congo OR Rwanda OR Comoros OR Eritrea OR Ethiopia OR Kenya OR Madagascar OR Mauritius OR Seychelles OR Somalia OR Sudan OR Tanzania OR Uganda OR Botswana OR Eswatini OR Swaziland OR Lesotho OR Malawi OR Mozambique OR Namibia OR "South Africa" OR Zambia OR Zimbabwe OR Benin OR "Burkina Faso" OR "Cabo Verde" OR Cameroon OR "Cote d'Ivoire" OR "Equatorial Guinea" OR Gabon OR Gambia OR Ghana OR Guinea OR Liberia OR Mali OR Mauritania OR Niger* OR "Sao Tome and Principe" OR Senegal OR "Sierra Leone" OR Togo OR "Lake Victoria" OR "Lake Tanganika" OR "Lake Malawi" OR "Lake Turkana" OR "Lake Kivu" OR "Lake Edward" OR "Lake Albert" OR "Lake Nakuru" OR "Lake Volta" OR "Lake Kyoga" OR "Lake Rukwa" OR "Lake Mweru" OR "Lake Kariba" OR "Lake Chad" OR "Lake Naivasha" OR "Lake Natron" OR "Lake Bogoria" OR "Lake Retba" OR "Lake Baringo" OR "Lake Tana" OR "Lake Bunyonyi" OR "Lake Nyo" OR "Lake Bangweulu" OR "Abaya Lake" OR "Lake Abaya" OR "Lake Manyara" OR "Lac de Mal" OR Sibayi OR "Cahora Bassa" OR "Lake Fundudzi" OR "Momella Seen" OR Momella-seen OR "Lake Tsimanampetsotsa" OR "Lake Monoun")*. Due to the search engines' limitations on number of search terms, the string of country and lake search terms was divided into three searches and results from each were combined. The specific mention of all the countries as well as the lakes was critical for including all relevant articles: while some article discussions were focused nationally, others focused on one or more lakes which often span trans-nationally.

A second search was conducted on 28th February 2023, also using the electronic databases Web of Science and Scopus. The second search was also limited to articles between 1990 and 2023. The string of search terms aimed to collect all literature concerning fish consumption in Sub-Saharan Aquaculture: *fish* AND consum* AND ("Sub-Saharan Africa" OR "Sub-Sahara Africa" OR Angola OR Burundi OR "Central African Republic" OR Chad OR Congo OR Rwanda OR Comoros OR Eritrea OR Ethiopia OR Kenya OR Madagascar OR Mauritius OR Seychelles OR Somalia OR Sudan OR Tanzania OR Uganda OR Botswana OR Eswatini OR Swaziland OR Lesotho OR Malawi OR Mozambique OR Namibia OR "South Africa" OR Zambia OR Zimbabwe OR Benin OR "Burkina Faso" OR "Cabo Verde" OR Cameroon OR "Cote d'Ivoire" OR "Equatorial Guinea" OR Gabon OR Gambia OR Ghana OR Guinea OR Liberia OR Mali OR Mauritania OR Niger* OR "Sao Tome and Principe" OR Senegal OR "Sierra Leone" OR Togo) NOT marine*.

The titles and abstracts of the search results for both searches were retained for review in a Microsoft Excel file (Version 16.73, Microsoft Corporation, 2018). The data was downloaded into an Excel file, which included authors, year of publication, title, total citation count, journal, and abstract.

(2) Compiling: Duplicates were removed for both search results. Then, titles and abstracts were reviewed for inclusion. Results were included if their titles and abstracts (a) specifically mentioned region(s) in Sub-Saharan Africa; and (b) discussed ‘aquaculture’, ‘fisheries’, ‘food security’, ‘food for humans’, ‘protein for humans’, or ‘fish consumption of humans’. Both qualitative and quantitative studies of all methodological designs were considered. A result was excluded if its abstract was unavailable, it was not a peer-reviewed article, it was in languages other than English (while French literature was also important, limited language capabilities prevented its review), it did not have a focus on sub-Saharan Africa, its topic was not directly related to fisheries, aquaculture, or fish consumption (e.g., current modelling, limnology, microplastics, water quality), or its focus was on marine or coastal environments. For example, environmental and geographical topics, like “A Comparative Introduction to the Biology and Limnology of the African Great Lakes,” were excluded, as were articles focused on marine environments, like “A novel approach in regional tuna fisheries management using low-resolution satellite data: a case study for the Gulf of Guinea”. Articles on fish oil supplements or fish nutrition were also excluded, like “Enhancing productivity of *Labeo victorinus* ponds using maize flour as a carbohydrate source”, unless they specifically mentioned a study area location in Sub-Saharan Africa. For this study, only aquatic animals were included; thus, literature on aquatic plants was excluded. African islands (Seychelles, Mauritius, Sao Tome) were also excluded. For example, a large body of literature on the Seychelles Child Development and Nutrition Study existed but was excluded because the study’s participants predominantly ate marine fish (Myers et al., 2003).

(3) Coded & Categorised: The remaining results’ titles and abstracts were reviewed and coded. Coding occurred thrice.

1. During the first coding cycle, ‘Domain and Taxonomic Coding’ methods were used (Saldaña, 2018) to categorise articles into whether the article discussed fish in the context of food security and if evaluating fish consumption was a central component of the methodology. ‘Fish consumption’ was considered central to the article if ‘fish intake’ or ‘micronutrient composition’ was a main measurement in the methodology and results. It was considered ‘not central’ if it was only mentioned for framing or conclusion purposes. Articles measuring contamination or heavy metal toxicity of an aquatic animal were excluded, as the research question was focused on nutrients rather than food safety. An article on heavy metal or contamination in fish was only included if it measured human health outcomes from eating the contaminated fish, but not if it only measured the heavy metal concentrations.
2. During the second coding cycle, ‘Domain and Taxonomic Coding’ methods were used again to categorise articles into ‘fisheries-focused’, ‘aquaculture-focused’, ‘dually focused’, or

‘neither’ groups, depending on whether fisheries, aquaculture, both, or neither were mentioned.

3. Within each of these main categories, articles were further categorised into thematic groups for the third coding cycle. To do this, articles’ titles and abstracts were coded using ‘Descriptive Coding’ methods (Saldaña, 2018). One or multiple codes were used for each abstract. Once all articles had codes, these codes were extracted and categorised into thematic clusters using ‘Code Mapping’ techniques, where codes were listed, arranged, and re-arranged into groups based on thematic similarities (Saldaña, 2018). Each group of codes was labelled with a descriptive thematic name. Once the codes were placed into categories, articles were assigned to a category based on its codes. For example, articles coded with *overfishing*, *translocation*, or *invasive species* were grouped to the ‘Environment & Conservation’ category. During categorisation, several articles could have fallen under multiple categories. For example, while ‘Ecology’ and ‘Governance’ became two distinct categories, some articles had some codes that had been grouped into the ‘Ecology’ category and others that had been grouped into the ‘Governance’ category, such that the article overlapped between two categories. In these cases, the paper’s framing emphasis guided to which category it was assigned.

Articles that examined the role of fish in food security as key findings were retained for in-depth review. The coding results were visualised using Miro Software (Miro, 2022).

(4) Summarised: Retained articles were reviewed in-depth and summarised. First, each article was read in full for content comprehension. Each article’s main findings were summarised and coded, again using ‘Descriptive Coding’ and then ‘Focused Grounded-Theory Coding’ (Saldaña, 2018) to develop a coherent narrative across this particular research landscape. While a cluster approach using an AI-supported software for coding abstracts (e.g., Budhathoki et al., 2022) may have been more efficient and allowed for statistical analysis, it was not appropriate for this review due to quality limitations of the publications. Several publications in this systematic literature review did not have abstracts that accurately represented their findings, and a manual iterative approach was essential for accurately classifying the articles. For instance, while many articles mentioned food security in their abstracts, which would have been picked up by an AI-supported coding software, their findings did not directly relate to conclusions about food security.

2.2 Results

The two searches resulted in 5,515 unique results, 2,409 of which were selected for review based on the inclusion criteria (Figure 1). The reviewed articles had study areas in 278 different waterbodies and 40 different countries (Table 1). Of the reviewed articles, 66% (n= 1,580 of 2,409) of the articles were fisheries focused, with a third (n=492 of 1,580) examining ecology & stock assessment specifically (Table 2).

Of the 2,409 included articles, 35% mentioned the role of fish in food security (n= 834) but only 25% actually examined it as part of their research aims (n=605). Of the 605, 48% (n=291) examined food safety (n=213 specifically on heavy metal concentrations), 36% (n=220) examined nutritional quality of the fish or its nutritional role in diets, and 11% (n=64) examined the socioeconomics of fish production on food security (Figure 2, where longer bars indicate more article within each category on the y-axis).

x

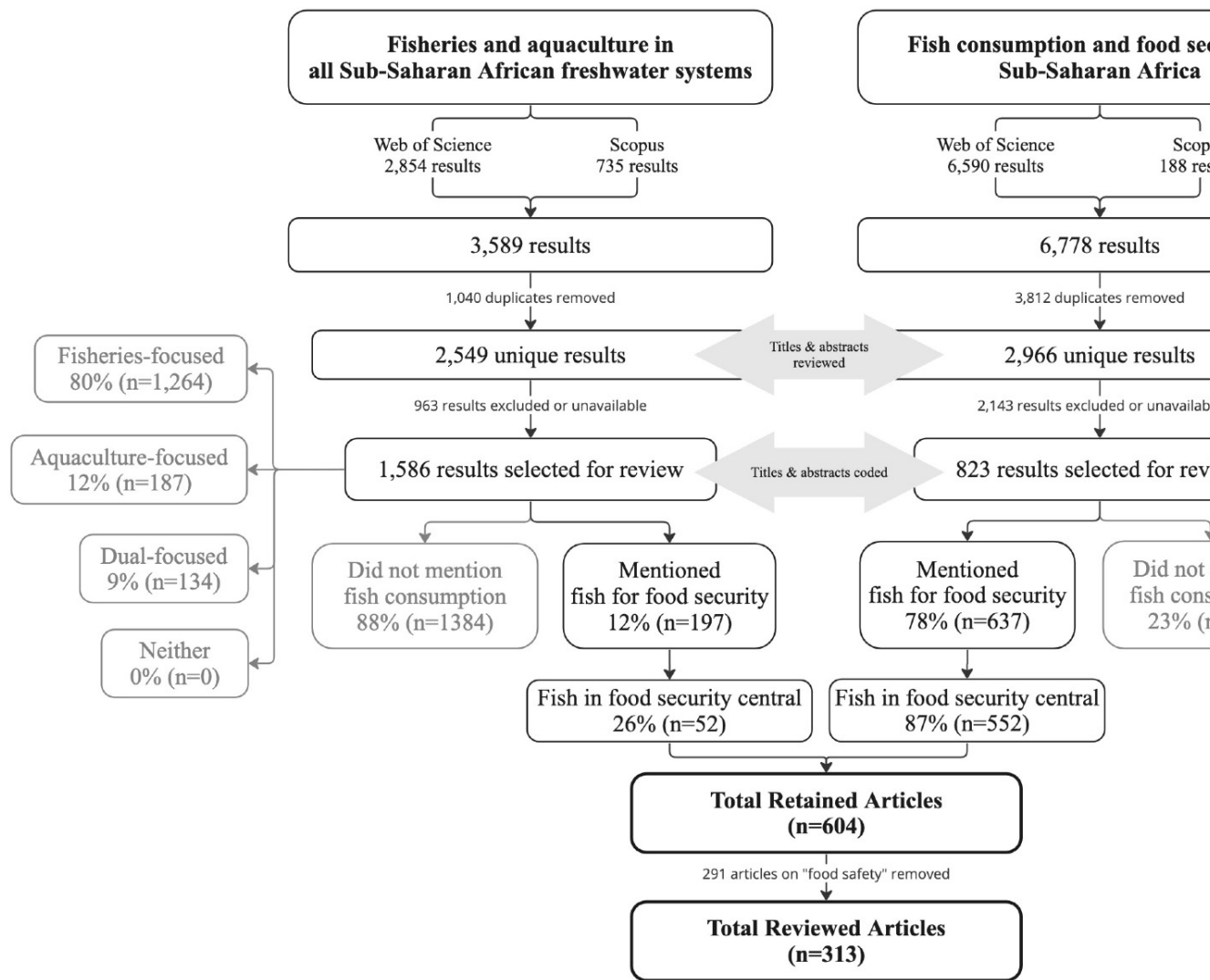


Figure 1: A schematic flow chart describing the number of articles resulting from the search to identify all articles related to fisheries or aquaculture in freshwater Sub-Saharan African environments.

Table 1: Percent of articles (that met the original inclusion criteria) by region and by waterbody of the articles' study area.

Region	Percent of articles with study area in that region	Waterbody	Percent of articles with study area in that waterbody
Nigeria	16% (n=317)	Lake Victoria	32% (n=404)
Kenya	12% (n=247)	Lake Malawi	10% (n=122)
South Africa	10% (n=198)	Lake Tana	5% (n=59)
Uganda	8% (n=153)	Lake Kariba	5% (n=60)
Tanzania	8% (n=152)	Lake Naivasha	3% (n=38)
Ethiopia	6% (n=127)	Lake Tanganyika	3% (n=35)
Malawi	5% (n=110)	African Great Lakes	2% (n=25)
Ghana	5% (n=102)	Lake Kivu	2% (n=19)
Zimbabwe	3% (n=67)	Lake Volta	2% (n=19)
Africa	2% (n=48)	Other	36% (n=450)
Zambia	2% (n=49)		
Benin	2% (n=37)		
East Africa	2% (n=37)		
Cameroon	2% (n=36)		
Other	16% (n=328)		

Table 2: Categories and sub-categories resulting from descriptive coding of included articles' titles and abstracts, with details on the proportion of each category that mentions fish consumption and those where fish consumption is central to their results and discussion.

Search	Category	Sub-category	Sub-category percent of total category	Percent fish in
All literature related to fisheries and aquaculture in all the Sub-Saharan African freshwater Lakes	80% Fisheries-focused (n=1264)	Ecology & stock assessment	34% (n=435)	6% (n=)
		Socio-economics	16% (n=200)	14% (n=)
		Fish biology, genetics, and disease	23% (n=296)	1% (n=)
		Environment and conservation topics	10% (n=126)	10% (n=)
		Governance	7% (n=93)	13% (n=)
		Fish consumption	7% (n=90)	52% (n=)
		Value chains	2% (n=24)	38% (n=)
		Total in Fisheries-focused category		11% (n=)
	12% Aquaculture-focused (n=187)	Technology	39% (n=73)	7% (n=)
		Development	16% (n=30)	13% (n=)
		Veterinary Science	14% (n=27)	7% (n=)
		Environmental impact	11% (n=20)	10% (n=)
		Food safety	6% (n=11)	82% (n=)
		Fish biology	9% (n=17)	0% (n=)
		Socio-economics	5% (n=9)	0% (n=)
		Total in Aquaculture-focused category		12% (n=)
	8% Dual-focused (n=130)	Environmental impact	22% (n=29)	10% (n=)
		Fish biology	45% (n=59)	17% (n=)
		Development	17% (n=22)	50% (n=)
		Technology	12% (n=15)	40% (n=)
		Food safety	4% (n=5)	100% (n=)
		Socio-economics	2% (n=2)	100% (n=)
		Consumer science	2% (n=2)	100% (n=)
		Total in Dual-focused category		27% (n=)
All categories				12% (n=)
All literature related to fish consumption	38% Fisheries-focused (n=316)	Fishers	23% (n=71)	37% (n=)
		Food safety	30% (n=93)	97% (n=)
		Ecology & stock assessment	18% (n=57)	11% (n=)

in Sub-Saharan Africa	Fish biology, behaviour, disease, and genetics	9% (n=29)	24% (n=7)
	Environment and conservation	6% (n=18)	50% (n=9)
	Fish consumption & consumer preferences	6% (n=19)	95% (n=18)
	Nutritional composition	4% (n=12)	100% (n=12)
	Governance	4% (n=14)	43% (n=6)
	Post-harvest	1% (n=2)	50% (n=1)
	Total in Fisheries-focused category		56% (n=175)
10% Aquaculture-focused (n=82)	Fish production	44% (n=36)	61% (n=22)
	Nutrition & human health outcomes	2% (n=2)	50% (n=1)
	Contaminants	16% (n=13)	100% (n=13)
	Disease & biosecurity	9% (n=7)	86% (n=6)
	Environmental topics	7% (n=6)	33% (n=2)
	Socio-economics	22% (n=18)	33% (n=6)
	Total in Aquaculture-focused category		61% (n=50)
3% Dual-focused (n=23)	Livelihoods	5% (n=7)	57% (n=4)
	Diets & nutrients	3% (n=4)	100% (n=4)
	Consumer demand	2% (n=2)	100% (n=2)
	Food safety	2% (n=3)	100% (n=3)
	Environment & conservation	2% (n=3)	100% (n=3)
	Governance	1% (n=1)	100% (n=1)
	Production technology	2% (n=3)	33% (n=1)
	Total in Dual-focused category		78% (n=18)
49% did not mention either (n=403)	Food safety	49% (n=196)	98% (n=192)
	Diets & nutrition	46% (n=186)	100% (n=186)
	Consumer science	1% (n=6)	100% (n=6)
	Socio-economics & value-chains	3% (n=12)	83% (n=10)
	Fish biology, ecology, & stock assessment	0% (n=2)	0% (n=0)
	Total in "none mentioned" category		98% (n=394)
All categories			77% (n= 637 of

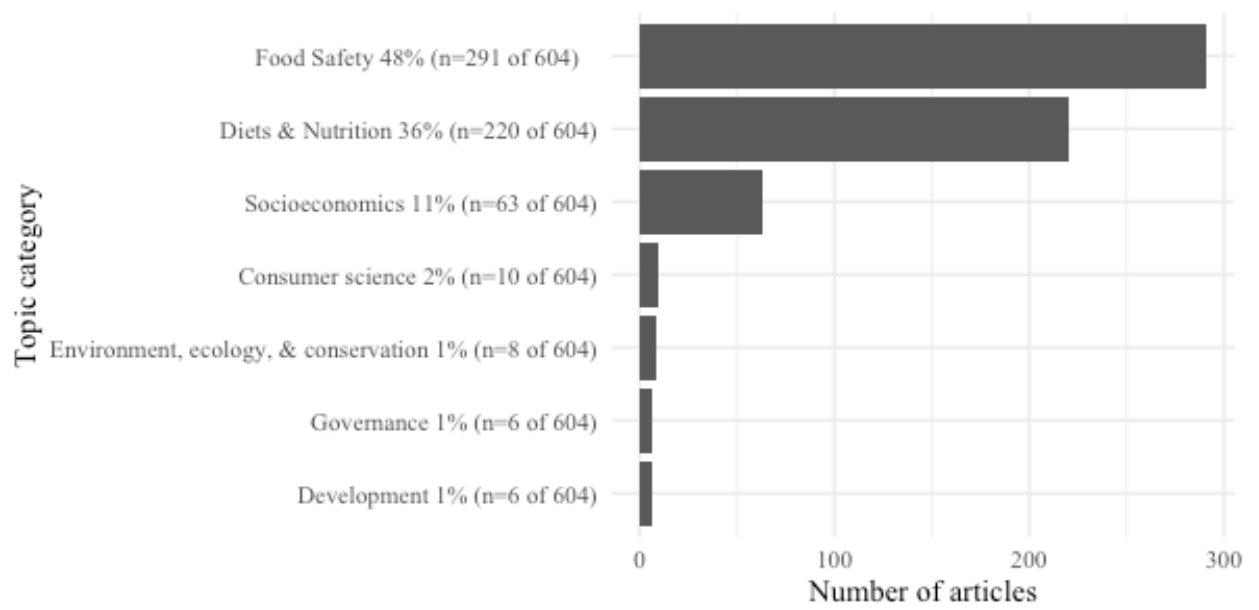


Figure 2: Categories resulting from descriptive coding of included articles' titles and abstracts, for articles considering the role of fish in food security.

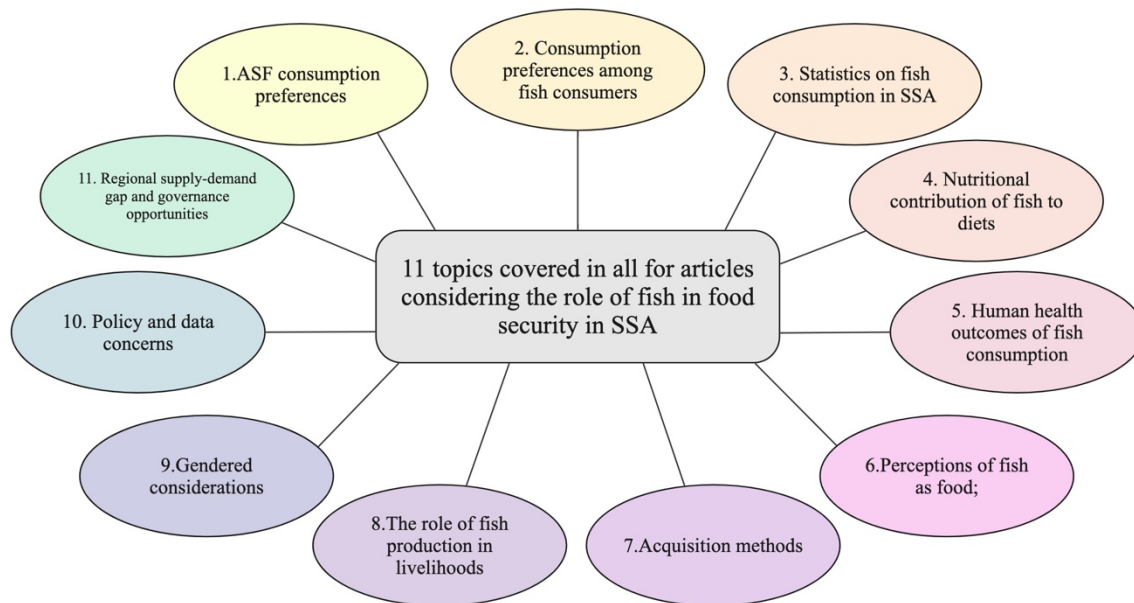


Figure 3: Thematic groupings resulting from coding of included articles regarding the role of fish in food security in SSA

The 314 articles were categorised into eleven topics (Figure 3). While each of these topics were examined in depth and used to inform this thesis, word count limitations for this thesis prevented me from including detailed results here. Rather, shorter summaries of each topic are presented with relevant references.

Animal Source Food (ASF) consumption preferences

The first theme was centred around ASF (defined as any food that was once an animal, e.g., chicken/ruminant meat, fish, eggs, etc) intake and preferences, which varied regionally (Gomna & Rana, 2007; Anderson et al., 2010; Randrianandrianina et al., 2010; Drimie et al., 2013; Herrador et al., 2014; Coetzee et al., 2015; Yigrem et al., 2015; Gashu et al., 2016; Workicho et al., 2016; Donovan & Gelli, 2019; Rakotomanana et al., 2020; Mingle et al., 2021; O’Meara et al., 2021; Wang et al., 2022). Much of the literature did not disaggregate between fish and other ASF and thus the specific role of fish was unclear (e.g., Ndekha et al., 2000; Nyahongo et al., 2009; Kuyper et al., 2017; Isabirye et al., 2020; Jordan et al., 2022; Liu et al., 2022). For many communities with generally low intakes of ASF, fish was the most important ASF (Hautvast et al., 1999; Were et al., 2008; Fa et al., 2009; Asiedu et al., 2016; Sumberg et al., 2016; Armar-Klemesu et al., 2018; Caswell et al., 2018; Colecraft et al., 2018; Malinda et al., 2018; Moreau & Garaway, 2018; Kaimila et al., 2019; Ansah et al., 2020; Minja et al., 2021; O’Meara et al., 2021). Small, dried fish were particularly important (Pfeiffer et al., 2001; Ferguson et al., 2015; Schulte-Herbrüggen et al., 2017). A portion of this literature examined dietary patterns and ASF preferences (De Merode et al., 2004; Gomna & Rana, 2007; Keriko et al., 2010; Naicker et al., 2015; Fargeot et al., 2017; Friant et al., 2019; Merson et al., 2019; Andriantsoa et al., 2020; Gelli et al., 2020; Brittain et al., 2022). People who preferred

fish cited taste, health benefits, and accessibility as key factors driving their preference (East et al., 2005; Duonamou et al., 2020). Indeed, the affordability of fish was important and also varied regionally (Nyahongo et al., 2009; Sumberg et al., 2016; Genschick et al., 2018; Traoré et al., 2018; Lo et al., 2019; Akuffo et al., 2020; Duonamou et al., 2020; Kyule et al., 2020; Akpaki et al., 2021; Armo-Annor et al., 2021; Chikowi et al., 2021; de Bruyn et al., 2021; Mottaleb et al., 2021; Brittain et al., 2022). Yet, for some people, a higher price of fish compared to other ASF did not deter them from eating fish, and in these communities, large portions of household expenditures could be spent on fish (Martin-Prevel et al., 2012; Sumberg et al., 2016; Ansah et al., 2020; Mingle et al., 2021). Whether fish were complimentary to or a substitution for other ASF also varied regionally (Tambi, 1996; Tambi 2001; Njelekela et al., 2003; Gomna & Rana, 2007; Fa et al., 2009; Nyahongo et al., 2009; Sumberg et al., 2016; Auma et al., 2019; Lo et al., 2019; Akuffo et al., 2020; Ansah et al., 2020; Duonamou et al., 2020).

Consumption preferences among fish consumers

The second theme focused on fish consumers and their preferences. Preferences varied by species, format, and region (East et al., 2005; Kyule et al., 2020; Thakwalakwa et al., 2020; Ayuya et al., 2021; Chikowi et al., 2021). While species are substitutes for one another (e.g., a person may eat tilapia or Nile perch), formats tend to be complimentary (e.g., a person may eat both dried and fresh tilapia; McNamara et al., 2019; Merson et al., 2019; Chikowi et al., 2021). Socio-economic factors and the affordability of fish influence consumption, where preserved and/or convenience products improve the accessibility of fish for many consumers and can be important salvage strategies (Pfeiffer et al., 2001; Mchazime & Kapute, 2018; Kyule et al., 2020; Ayuya et al., 2021; Chikowi et al., 2021; Liverpool-Tasie et al., 2021; Moreau & Garaway, 2021; Wang et al., 2022). Like for other ASF, affordability was a key factor highlighted by the literature. Affordability was linked to the size and species of fish, where poorer consumers preferred smaller fish for their affordability and portionability (Brummett, 2000; Pfeiffer et al., 2001; Genschick et al. 2018; Marinda et al., 2018; Moreau & Garaway, 2018; Kyule et al., 2020; Ayuya et al., 2021; Moreau & Garaway, 2021; Wang et al., 2022; Kaminski et al, *in prep*). Generally, price is a significant barrier to fish intake in Sub-Saharan Africans due to poverty rates that limit the available income for fish purchasing (Beveridge et al., 2013; Kyule et al., 2020). Consumers in SSA, particularly the poor, make trade-offs between price, quality, and format (East et al., 2005; Oishi & Hagiwara 2015; Donovan & Gelli, 2019; Ayuya et al., 2021; Obura, 2024). Thus, as they make these trade-offs, consumers consider organoleptic qualities of the fish to judge quality (Oyieng et al., 2013; Mchazime & Kapute, 2018; Ayeloja et al., 2020; Bothma et al., 2020; Chunda-Liyoka et al., 2020; Chikowi et al., 2021).

Statistics on fish consumption in SSA

The third theme described fish consumption rates. While the fish consumption rate across SSA is one of the lowest globally (8.9 kg compared to 20kg per capita globally in 2022), the consumption

in certain regions far surpasses global averages, for example in Ghana (25-37.6 kg per capita), Uganda (70kg per capita), Equatorial Guinea (109 kg per capita), among others (Kipkemboi et al., 2007; Fa et al., 2009; Anderson et al., 2010; Welcomme, 2011; Asiedu et al., 2016; Schulte-Herbrüggen et al., 2017; Fiorella et al., 2018; Moreau & Garaway, 2018; Lo et al., 2019; Obiero et al., 2019; Gelli et al., 2020; Mingle et al., 2021; Mottaleb et al., 2021; Sanusi et al., 2021; FAO, 2022; Kaminski et al., 2022). This emphasises fish consumption variability throughout SSA. In Nigeria alone, the average national fish consumption per capita is 3.3 kg annually (Sanusi et al., 2021), whereas rural populations can eat up to 285 kg of fish or 153 kg of freshwater fish per capita annually (Lo et al., 2019). One key finding was that nationally aggregated statistics can be misleading, often underestimating or containing too much variance within sub-populations to be representative (Torheim et al., 2001; Malenganisho et al., 2007; Keriko et al., 2010; Borgerson, 2016; Fargeot et al., 2017; Koma & Lebelo, 2017; Desiere et al., 2018; Hemsworth et al., 2018; Emerole et al., 2018; Moreau & Garaway, 2018; Merson et al., 2019; Ayuya et al., 2021; Mingle et al., 2021; Mottaleb et al., 2021; Ngimbudzi et al., 2021; FAO, 2022; Simmance et al., 2022). Additionally, frequency and portion size also vary by region, affordability, demographic (e.g., gender), fish species and fish format (Ndekha et al., 2000; Lykke et al., 2002; Gibson et al., 2003; Merchant et al., 2005; Malenganisho et al., 2007; Pachón et al., 2007; Were et al., 2008; Coulibaly et al., 2009; Fa et al., 2009; Keriko et al., 2010; Daboné et al., 2013; Mesele et al., 2014; Bobo et al., 2015; Coetzee et al., 2015; Ferguson et al., 2015; Sumberg et al., 2016; Ochieng et al., 2017; Onynago 2017; Randrianarison et al., 2017; Schulte-Herbrüggen et al., 2017; Armar-Klemesu et al., 2018; Caswell et al., 2018; Colecraft et al., 2018; Desiere et al., 2018; Emerole et al., 2018; Ibeanu et al., 2018; Marinda et al., 2018; Moreau & Garaway, 2018; Downs et al., 2019; Kaimila et al., 2019; Lo et al., 2019; Merson et al., 2019; Abdelmenan et al., 2020; Ansah et al., 2020; Kyule et al., 2020; Modjadji et al., 2020; Onumah et al., 2020; Armo-Annor et al., 2021; Ayuya et al., 2021; Chikowi et al., 2021; Kalliokoski et al., 2021; Sanusi et al., 2021; Tiruneh et al., 2021; Visser et al., 2021; Bottin et al., 2022; Kaminski et al., 2022, Simmance et al., 2022; Wang et al., 2022). Tilapia (mainly *Oreochromis spp.*) and the Lake Victoria sardine (known as ‘omena’ in Duluo and ‘dagaa’ in Swahili; *Rastrineobola argentea*) were mentioned most frequently in the literature (Gomna & Rana, 2007; Kipkemboi et al., 2007; Keriko et al., 2010; Fiorella et al., 2016; Fiorella et al., 2018).

Nutritional contribution of fish to diets

The fourth theme described the literature concerning the nutritional value of fish in overall diets. SSA suffers from a paradox, as the overall region has a comparatively low fish consumption, but sometimes a high dependence on nutrient-rich fish for nutrition (Beveridge et al., 2013; Obiero et al., 2019; Kaminski et al., 2022). In SSA, fish is important in nutrient provisioning and achieving dietary diversity, although dietary patterns can influence its inclusion (Charlton et al., 1998; Ndekha et al., 2000; Savy et al., 2008; Labadarios et al., 2011; Becquey et al., 2012; Gimou et al., 2013; Spearing et al., 2013; Caswell et al., 2015; Ntwenya et al., 2015; Watts et al., 2015; Ferede et al.,

2017; Fiorella et al., 2018; Holmes et al., 2018; Ogum Alangea et al., 2018; Abizari et al., 2019; Del Prete et al., 2019; Delarue, 2019; Kang et al., 2019; Djossinou et al., 2020; Modjadji et al., 2020; Adjei-Banuah et al., 2021; Akpaki et al., 2021; Holmager et al., 2021; Armo-Annor et al., 2021; O'Meara et al., 2021; Visser et al., 2021; Kaminski et al., 2022). Not only are fish nutritionally dense (Watts et al., 2015), fish can also encourage consumption of other healthy foods through traditional food pairings and recipes. The relative importance of nutrients from fish is dependent on other foods present in the diet. Overall, the literature suggested that fish were relatively important; however, this is likely due to the sampling methods of this review, which aimed to identify articles highlighting fish consumption. Regardless, when fish are consumed, they are major contributors to micronutrient intake, particularly for n-3 PUFAs (EPA and DHA) that are only available in aquatic products. Other notable micronutrients provided through fish include vitamin D, zinc, iron, iodine, cobalt, selenium, and calcium (Watts et al., 2015; Delarue, 2019; KushKush et al., 2022). However, the micronutrient contribution of fish depends on the species, size, quantity and source of the fish consumed (Prentice et al., 1993; Gibson et al., 2003; Turon et al., 2005; Sullivan et al., 2006; Okonji & Anoma, 2007; Keriko et al., 2010; Watts et al., 2015; Gabete et al., 2017; Jim et al., 2017; Compaore et al., 2020; Kigozi et al., 2020; Tiruneh et al., 2021; Bayissa et al., 2022; Clarke et al., 2022). In particular, the literature identified small fish as more nutritious than large fish (Robert et al., 2014; Jimenez et al., 2015; Kasozi et al., 2018; Nölle et al., 2020; Bennett et al., 2022; Clarke et al., 2022; Kaminski et al., 2022). Portioning, preservation, and cooking methods all affect the nutritional offerings of fish to consumers (Prentice et al., 1993; Asiedu & Sanni 2002; Gimou et al., 2013; Gimou et al., 2014; Icard-Vernière et al., 2015; Kapute & Lipato, 2017; Alozie & Ene-Obong, 2018; Kasozi et al., 2018; Mchazime & Kapute, 2018; Adadi et al., 2019; Chaula et al., 2019; Kigozi et al., 2020; Nölle et al., 2020; Tenyang et al., 2020; Moreau & Garaway, 2021; Tadesse Zula et al., 2021; Zula & Desta 2021; KushKush et al., 2022). Overall, the dietary inclusion of fish increased micronutrient intake, and was thus recommended to address micronutrient deficiencies (Ferguson et al., 1995; Gibson et al., 2003; Ekweagwu et al., 2008; Hong et al., 2013; Herrador et al., 2014; Ferguson et al., 2015; Caswell et al., 2018; Talsma et al., 2018; Del Prete et al., 2019; Phiri et al., 2019; Elolu & Ongeng 2020; de Bruyn et al., 2021). While heavy metals and food safety is a critical topic when considering how fish contributes to food security and was investigated by a significant portion of the literature, food safety is not the focus of this literature review and a specific review is warranted.

Human health outcomes of fish consumption

This leads into our fifth theme about human health outcomes from fish consumption. Fish consumption was generally linked to reduced prevalence of noncommunicable diseases, including cancer, diabetes, cardiovascular disease, cognitive dysfunction, and anaemia (Pauletto et al., 1996; Broadhurst et al., 1998; Rutakingirwa et al., 1999; Winnicki et al., 2002; Wolmarans et al., 2003; Kumar et al., 2009; Jordan et al., 2013; Akinyemi et al., 2014; Frank et al., 2014; Pilleron et al., 2015; Ferede et al., 2017; Galbete et al., 2018; Olatona et al., 2018; Chajès et al., 2019; Delarue, 2019;

Jordaan et al., 2020; Motswagole et al., 2020; Tonui et al., 2020; Mohan et al., 2021; Mosha et al., 2021; Ngimbudzi et al., 2021). A large portion of the literature described the importance of fish consumption among breastfeeding mothers, to supply their infants with PUFAs, and among children, to lower their nutrient deficiencies (Rocquelin et al., 1998; Kuipers et al., 2005; Geheb et al., 2008; Nyuar et al., 2013; Mesele et al., 2014; Jimenez et al., 2015; Adjepong et al., 2018; Fiorella et al., 2018; Marinda et al., 2018; Siziba et al., 2020; Byrd et al., 2021; Bottin et al., 2022; Rasolofoson et al., 2022). Indeed, poor health outcomes were linked to a lack of fish in children's diets (Hotz & Gibson 2001; Colecraft et al., 2006; Turyashemererwa et al., 2013; Egbi et al., 2015; Mohamed et al., 2018; Khamis et al., 2019; Tandoh et al., 2019; Visser et al., 2021). Again, the effects of fish consumption varied regionally and were sometimes not correlated with health outcomes (Schoeman et al., 1991; Gibson et al., 2003; Malenganisho et al., 2007; Mwandri et al., 2014; Melaku et al., 2018; Kaimila et al., 2019). Food pairings can affect the overall nutritional value of the meal, where the consumption of fish might encourage the consumption of less nutritious foods alongside it; relatively small amounts of fish can enhance the overall nutritional sufficiency of an otherwise plant-based diet (Njelekela et al., 2002; Njelekela et al., 2003; Tang et al., 2019; Okeyo et al., 2020; Eberet al., 2021; Song et al., 2021). But simply encouraging greater fish consumption might have unintended nutritional consequences: dagaa is traditionally paired in small portions with larger portions of ugali, often maize-based and with a high glycemic index, and encouraging greater consumption of dagaa might also encourage greater consumption of maize that can increase the risk of diabetes (Eberet al., 2021). The format of the fish also affected health outcomes. Fried fish was related to high blood pressure in Tanzania (Njelekela et al., 2003) and to obesity in South Africa (Okeyo et al., 2020), while smoked fish had detrimental consequences for producers due to the carcinogenic properties of inhaling smoke (Armo-Annor et al., 2021). Regardless, the literature seemed to suggest that eating fish of any format was more beneficial than no fish consumption (Kuipers et al., 2005; Colecraft et al., 2018; Armo-Annor et al., 2021; Geßner et al., 2021; Wiafe et al., 2021). In addition, the literature explained how more research is required, particularly around research methodologies: robust data acquisition can be challenging (Dop et al., 1994; Eaton et al., 2019), and many studies do not disaggregate between fish species or format (e.g., Pauletto et al., 1996; Charlton et al., 1998; Hotz & Gibson 2001; Lykke et al., 2002; Colecraft et al., 2006; Kumar et al., 2009; Randrianandrianina et al., 2010; Labadarios et al., 2011; Drimie et al., 2013; Jordan et al., 2013; Turyashemererwa et al., 2013; Akinyemi et al., 2014; Frank et al., 2014; Naicker et al., 2015; Pilleron et al., 2015; Borgerson, 2016; Gashu et al., 2016; Workicho et al., 2016; Adjepong et al., 2018; Alemu & Azadi 2018; Galbete et al., 2018; Marinda et al., 2018; Melaku et al., 2018; Mohamed et al., 2018; Olatona et al., 2018; Del Prete et al., 2019; Kaimila et al., 2019; Ravaoarisoa et al., 2019; Ansah et al., 2020; Jordaan et al., 2020; Motswagole et al., 2020; Siziba et al., 2020; Tonui et al., 2020; Akpaki et al., 2021; Mohan et al., 2021; Visser et al., 2021; Manyong et al., 2022; Rasolofoson et al., 2022; Bottin et al., 2022), both of which can affect the nutritional and health benefits of the fish product.

Perceptions of fish as food

The sixth theme was concerning people's perception of fish. It described certain religions and ethnicities that discourage fish consumption (Njelekela et al., 2003; Gomna & Rana, 2007; Prendergast 2010; Amare et al., 2012; Towns et al., 2013; Chege et al., 2015; Kebede & Gubale, 2016; Tonui et al., 2020; Ayuya et al., 2021; Geppert et al., 2021). It also described taboos around eating fish. A particular portion of the literature described taboos around fish consumption during pregnancy (Zerfu et al., 2016; Armar-Klemesu et al., 2018; Fasola et al., 2018; Traoré et al., 2018; Chakona & Shackleton 2019; Chunda-Liyoka et al., 2020; Adjei-Banuah et al., 2021; Ramulondi et al., 2021). While some people thought fish consumption during pregnancy was beneficial for the baby and its birthing, others thought it would cause poor welfare for the baby and/or mother. Among fish eaters, nutritional value, taste, and affordability were cited as key reasons for eating fish (Abdulai & Aubert, 2004; Towns et al., 2013; Bobo et al., 2015; Andrew et al., 2016; Folasire et al., 2016; Kyule et al., 2020; Thakwalakwa et al., 2020; Mingle et al., 2021;). Fishers perceived fish as both food and cash (Geheb & Binns, 1997; Mmopelwa et al., 2009; Downing et al., 2014; Fiorella et al., 2014; Andrew et al., 2016; Moreau & Garaway, 2018; Sanon et al., 2021; Kaminski et al., 2022). Only two articles discussed consumer satisfaction about their fish consumption (Were et al., 2008; Johnson, 2017), and more research is needed.

Acquisition methods

The seventh theme arising from this literature was about how people acquire fish. Most people acquire fish through purchasing rather than through subsistence (Lykke et al., 2002; De Merode et al., 2004; East et al., 2005; Kipkemboi et al., 2007; Ohiokpehai et al., 2007; Randrianandrianina et al., 2010; Coetzee et al., 2015; Fiorella et al., 2016; Schulte-Herbrüggen et al., 2017; Moreau & Garaway, 2018; Merson et al., 2019; Chiebonam et al., 2020; Wang et al., 2022). Thus, the general availability of fish in markets, and a consumer's distance to a waterbody or a market selling fish all affected fish consumption (De Merode et al., 2004; Nyahongo et al., 2009; Keriko et al., 2010; Megersa et al., 2014; Coetzee et al., 2015; Ferede et al., 2017; Amevenku & Asravor, 2019; Friant et al., 2019; Lo et al., 2019; Merson et al., 2019; Kyule et al., 2020; Fiorella et al., 2021; Nchanji & Lutomia 2021; O'Meara et al., 2021; Bennett et al., 2022; Simmance et al., 2022; Wang et al., 2022). People closer to waterbodies or markets were more likely to eat more fish, as proximity to markets and waterbodies increased the accessibility of fish for consumers (De Merode et al., 2004; Nyahongo et al., 2009; Coetzee et al., 2015; Ferede et al., 2017; Lo et al., 2019; Merson et al., 2019; Kyule et al., 2020; O'Meara et al., 2021; Bennett et al., 2022; Simmance et al., 2022; Wang et al., 2022). People in urban areas were more likely to consume fish and spend more on fish products than rural areas (Brummett, 2000; Savy et al., 2008; Galbete et al., 2017; Thakwalakwa et al., 2020; Bennett et al., 2022; Wang et al., 2022). Acquisition of fish through purchasing may explain why fish consumption was linked to wealth in so many contexts (De Merode et al., 2004; Alaofè et al., 2016; Schulte-Herbrüggen et al., 2017; Merson et al., 2019; Abdelmenan et al., 2020; Bundala et al., 2020; Gelli et al., 2020;

O'Meara et al., 2021; Simmance et al., 2022). Notably, fish was not associated with wealth in all areas (Nyahongo et al., 2009; Genschick et al., 2018; Lo et al., 2019). Dried fish improved the affordability and accessibility of fish (Geheb & Binns, 1997; Ohiokpehai et al., 2007; Schulte-Herbrüggen et al., 2017; Emerole et al., 2018; Ryckman et al., 2021; Simmance et al., 2022). As preservation methods (drying, smoking and fermentation) extend the shelf-life of the fish, preserved fish enable access for the many people in SSA without access to cold-chain facilities and larger geographic areas of trade, both into rural areas and internationally to the Sub-Saharan Africa diaspora in other continents (Oishi & Hagiwara 2015; Asiedu et al., 2016; Fargeot et al., 2017; Okoro et al., 2017; Schulte-Herbrüggen et al., 2017; Asiedu et al., 2018; Adadi et al., 2019; Liverpool-Tasie et al., 2021; Moreau & Garaway, 2021; KushKush et al., 2022; Simmance et al., 2022). Preserved fish – particularly small, dried fish, previously identified as nutrient-rich and accessible to the poor – also enable fish consumption in periods where fresh fish are unavailable (De Merode et al., 2004; Gomna & Rana, 2007; Beveridge et al., 2013; Towns et al., 2013; Genschick et al., 2018). Indeed, seasonality affects how people acquire fish and some people switch acquisition strategies throughout the year (East et al., 2005; Abbott et al., 2007; Beveridge et al., 2013; Ntwenya et al., 2015; Borgerson, 2016; Fargeot et al., 2017; Randrianarison et al., 2017; Moreau & Garaway, 2018; Bosha et al., 2019; Ravaoarisoa et al., 2019; Gelli et al., 2020; Thakwalakwa et al., 2020; de Bruyn et al., 2021; Mingle et al., 2021; Bottin et al., 2022; Brittain et al., 2022; Kaminski et al., 2022). While both fish farmers and fishers were known to sometimes retain a portion of their catch, income generated from fish sales generally seemed to be more important than direct provisioning for household consumption and food security, again, because food is mostly purchased in markets and purchasing power is key (Hautvast et al., 1999; De Merode et al., 2004; Abbott et al., 2007; Gomna & Rana, 2007; Were et al., 2008; Béné et al., 2009; Ellender et al., 2009; Mmopelwa et al., 2009; Towns et al., 2013; Fiorella et al., 2016; Randrianarison et al., 2017; Alemu & Azadi, 2018; Moreau & Garaway, 2018; Ansah et al., 2020; Fiorella et al., 2021; Minja et al., 2021; Sanon et al., 2021; Atijm et al., 2022; Liu et al., 2022; Onyenekwe et al., 2022). Yet, income only from fishing was insufficient and most fishers had several income-generating activities (Hautvast et al., 1999; Gomna & Rana, 2007; Fiorella et al., 2014; Muringai et al., 2020). Fishers are particularly concerned about their income from fishing, as they perceive that fisheries are declining and their catch-per-unit-effort is decreasing (Kipkemboi et al., 2007; Towns et al., 2013; Eggert et al., 2015; Lo et al., 2019). In the future, fish farming could support local food security by increasing the volumes of fish in markets as well as generating income for fish farmers, with potential economic knock-on effects for the community (Hishamunda et al., 1998; Kipkemboi et al., 2007; Beveridge et al., 2013; Asiedu et al., 2016; Limuwa et al., 2018; Akuffo & Quagrainie 2019; Byrd et al., 2021; Avadí et al., 2022; Kaminski et al., 2022).

The role of fish production in livelihoods

The eighth theme explored how both fisheries and aquaculture support livelihoods in SSA, where certain communities are disproportionately reliant on fish value-chain livelihoods (Geheb & Binns,

1997; Andrew et al., 2007; Béné et al., 2009; Johnson, 2017; Onyango, 2017; Muringai et al., 2020; Atijm et al., 2022; FAO, 2022). Engagement in fishing, fish processing, fish trading, and recreational fishing employment are all used to supplement and diversify income streams for households (Geheb & Binns, 1997; Ellender et al., 2009; Hara, 2011; Downing et al., 2014; Oishi & Hagiwara 2015; Onyango, 2017; Limuwa et al., 2018; Moreau & Garaway, 2021; Brittain et al., 2022; Ragsdale et al., 2022). Fish can provide nutrition and cash during lean periods and cushion shocks. Critically, fishing is highly accessible and thus available as a back-up income-generating activity (Ellender et al., 2009; Overå, 2011; Weyl & Cowley, 2015; Moreau & Garaway, 2021; Sanon et al., 2021). This is particularly true for the poor, the unemployed, and among migrants from even poorer areas without access to fish because entry into the fishing sector is generally low-cost (Geheb & Binns, 1997; Were et al., 2008; Ellender et al., 2009; Weyl & Cowley, 2015; Alemu & Azadi, 2018). Indeed, many fishers are poor and subsistence fishing supports food security in many areas, particularly during lean periods (Béné et al., 2009; Mmopelwa et al., 2009; Ellender et al., 2010; Coetzee et al., 2015; Weyl & Cowley, 2015; Simmance et al., 2022). Because of its accessibility, participation in the fishing value-chain may alleviate poverty in certain, but not all, areas (Béné et al., 2010). Participation in the fishing value-chain was associated with lower poverty rates in a study area in Tanzania (Moreau & Garaway, 2018) but not in other study areas of Tanzania or Malawi (Simmance et al., 2022). Yet, fishing communities were characterised by significant inequalities and vulnerabilities to shocks (Brummett, 2000; De Merode et al., 2004; Ngwenya & Mosepele 2007; Hara, 2011; Downing et al., 2014; Johnson, 2017; Berthe et al., 2019; Temesgen et al., 2019; Fiorella et al., 2021). A major challenge fishers face is declining catch-per-unit-effort and anthropogenic environmental degradation (Munthali, 1997; Hara, 2011; Andrew et al., 2016; Berthe et al., 2019; Atijm et al., 2022). In contrast, the introduction of invasive species can, albeit often in “boom and bust cycles”, economically support fisheries industries, , with complex implications for local food security (Ellender et al., 2010). For example, the Nile perch boom in Lake Victoria stimulated the local economy, but the Lake’s changing ecology had repercussions for the diversity of fish for consumption (Chapter 3; Geheb et al., 2008; van der Knapp & Ligtvoet, 2010; Eggert et al., 2015). The introduction of marbled crayfish in Madagascar negatively affected rice production, due to the crayfish burrowing habits that dig up rice plants, and fishing, as crayfish predate on juvenile fish (Andriantsoa et al., 2020). However, its harvest, sales, and consumption as a cheap ASF in the context of Madagascar’s high malnutrition rates supported livelihoods and food purchasing power (Andriantsoa et al., 2020). Livelihoods are highly dependent on these fisheries and vulnerable to their boom-and-bust cycles (Geheb et al., 2008; van der Knapp & Ligtvoet, 2010; Eggert et al., 2015). As a solution to these challenges, many authors suggest converting fishers to fish farmers, reducing fishing pressure and providing alternative income-generating activities (Iruo et al., 2018; Limuwa et al., 2018; Gronau et al., 2020; Sanon et al., 2021). However, this transition has its challenges: a lack of human capacity and the perceived risks of aquaculture are significant barriers and must be addressed to develop aquaculture (Limuwa et al., 2018). Both smallholder aquaculture and

commercial-scale aquaculture can support food security through increased availability of fish in markets and employment opportunities and reduce inequalities within communities due to the knock-on effects of its economic activity (Hishamunda & Ridler, 2006; Kaliba et al., 2007; Gronau et al., 2020). Yet, the introduction of aquaculture should be monitored, as it can cause social disruption: for instance, *acajas* (hybrid fishing-aquaculture technologies in Ghana) have increased income inequalities (i.e., a subset of people increased their income), but simultaneously increased the local economy's vibrancy through employment generation and cash injection, and area's average income increased (Béné & Obirih-Opareh, 2009; Amevenku & Asravor, 2019).

Gendered considerations of the role of fish in food security

The ninth theme explored gendered aspects of fish consumption and fish-derived livelihoods. Fish consumption is gendered, where men typically eat more fish than women (Gomna & Rana, 2007; Amare et al., 2012; Galbete et al., 2017; Ochieng et al., 2017; Kyule et al., 2020; de Bruyn et al., 2021; Mingle et al., 2021). In some cases, this is likely due to men's generally larger size, but differences were sometimes extreme: for instance, Nigerian male heads of households ate 59% more fish than other members of the family (Gomna & Rana, 2007). Some studies attributed this difference to differences in wealth: because men were generally wealthier than women, they ate more fish (fish consumption as an outcome of wealth was also seen other themes; Ochieng et al., 2017; Chikowi et al., 2021; Mingle et al., 2021). Gendered differences in fish consumption may also be due to traditional gendered perceptions of consumption, for example, where certain genders are perceived to have different preferences around fish consumption (Gomna & Rana, 2007; Chege et al., 2015; Moreau & Garaway, 2021). Household nutrient distribution can result in nutritional inequalities where men might be more likely to meet or exceed their recommended nutrient intake than women, for example, as in Bangladesh (Mamun 2016). Yet, this topic is understudied in SSA (de Bruyn et al., 2021). The literature also described participation in the fishing value-chain as highly gendered (Moreau & Garaway, 2018). While both men and women participated in all nodes of the value-chain, fishing was dominated by men while processing and trade was generally dominated by women (Ndekha et al., 2000; Abbott et al., 2007; Geheb et al., 2008; Ellender et al., 2009; Abbott et al., 2015; Mussa et al., 2017; Onyango, 2017; Alemu & Azadi, 2018; Muringai et al., 2020; Moreau & Garaway, 2021; Bennett et al., 2022; Ragsdale et al., 2022). Men similarly dominated the aquaculture value-chain (Limuwa et al., 2018; Iruo et al., 2018). Regardless of the node, women face significant barriers to their participation and were marginalised (Abbott et al., 2007; Abbott et al., 2015; Johnson, 2017; Onyango, 2017; Moreau & Garaway, 2018; Moreau & Garaway, 2021; Sanon et al., 2021); yet, when women did participate in the value-chain, they retained a larger portion of fish for household consumption and prioritised cash from fish sales for household expenses, including food (Pfeiffer et al., 2001; Merten & Haller, 2008; Béné et al., 2009; Moreau & Garaway, 2018; Ansah et al., 2020). Thus, women's exclusion and marginalisation from the fishing value-chain may be

negatively affecting household food security (Geheb et al., 2008). None of the literature explored differences in generation or age.

Policy and data concerns

The tenth theme focused on policy and data. Firstly, authors found that fish were under or misrepresented within policy documents (van der Knaap, 2013). For instance, despite that Ghanaians of all economic classes use fish as their main source of protein and consume it almost daily, fish is only mentioned once in the Ghanaian national nutritional strategy (Sumberg et al., 2016). Acknowledgement of the critical role of fish in food security was often lacking or poorly integrated into national policies (Aura et al., 2022). As one example, Kenyan fisheries policies had poor integration between fisheries, health, and trade, particularly concerning small indigenous species (SIS) that support local food security (Aura et al., 2022). As a result, policies were often ineffective or insufficient to support activities within the fish value-chain (Overå, 2011; Fiorella et al., 2016; Johnson, 2017; Mussa et al., 2017; Sanon et al., 2021). While Kenyan fisheries regulations limit Nile perch catch around Lake Victoria, lake-shore residents still ate Nile perch that was mainly below the minimum catch size, with implications for fisheries sustainability (Fiorella et al., 2016). When fish was considered in national policy, it overly focused on export-oriented trade, ignoring the immense value of small fish for local consumption (Gibbon, 1997; Béné et al., 2010; Johnson, 2017; Schubert et al., 2021; Aura et al., 2022; Bennett et al., 2022). Kenyan policies focused on Nile perch, conspicuous for its export value, and ignored that local households remained undernourished and relied on “purchased, low value, small size, and illegally caught fish” (Fiorella et al., 2016). Indeed, small-scale fisheries in SSA are undermonitored, underreported, and understudied (Weyl et al., 2007; Welcomme, 2011; McCafferty et al., 2012; Weyl & Cowley, 2015; Schubert et al., 2021; Marivoet & Ulimwengu, 2022). Secondly, conservation was often framed as a trade-off to food security, and aquaculture was characterised as an alternative and solution to fishing. Yet, the evidence suggests that aquaculture and fisheries are complimentary for food security and should be considered synergistically (Beveridge et al., 2013; Limuwa et al., 2018; Sanon et al., 2021; Kaminski et al., 2022; Olaifa et al., 2022). Thirdly, fishing communities are described as being in a state of crisis, despite that many individuals are deriving substantial livelihoods from fisheries resources (Sumberg et al., 2016; Johnson, 2017; Fiorella et al., 2018).

Regional supply-demand gap and governance opportunities to support fish consumption and production

The eleventh theme concerned the market dynamics of supply and demand in SSA. Inland catch is generally increasing over time, with regional variations where some countries in SSA are among the top inland fisheries producers globally (Welcomme, 2011; FAO, 2022). In contrast, aquaculture has generally stagnated, also with regional variations (FAO, 2022). While aquaculture production in all areas except Nigeria has increased, the recent production decrease in Nigeria was large enough to

cause overall stagnation (FAO, 2022). Generally, high-value fish are exported and low-value fish are retained for local consumption (Welcomme, 2011; Oyieng et al., 2013; Mussa et al., 2017; Chan et al., 2019; FAO, 2022). Yet, fish retained for local consumption drastically undersupplies demand (Sumberg et al., 2016; Chan et al., 2019; Obiero et al., 2019; Busari & Ayanboye, 2022; FAO, 2022; Olaifa et al., 2022). Thus, SSA is highly reliant on imported fish, a trend that is expected to increase over time with a growing and increasingly affluent population (Abdulai & Aubert, 2004; Desiere et al., 2018; Mottaleb et al., 2021). Several authors modelled solutions to increased demand of fish in SSA, showing that aquaculture development would improve local fish supply and would complement rather than replace supply from imports or fisheries (Beveridge et al., 2013; Kebede & Gubale, 2016; Oyase & Jemerigbe, 2016; Obiero et al., 2019; Gronau et al., 2020; Busari & Ayanboye, 2022; Olaifa et al., 2022; Nyamweya et al., 2022). The development of aquaculture is generally envisioned as a compliment rather than a replacement for fisheries (Beveridge et al., 2013; Limuwa et al., 2018; Chan et al., 2019; Sanon et al., 2021; Kaminski et al., 2022; Olaifa et al., 2022).

2.3 Discussion

This systematic review collated 605 articles that considered the role of fish in food security. The dual approach – searching for fisheries and aquaculture in SSA and also fish consumption in food security – was corroborated by the results (Figure 1), where each search and filtering process returned a different set of articles, both of which were relevant to review. Almost half of these articles focused on food safety, particularly heavy metals. This may suggest that the dominant rhetoric is framed around contamination; paradoxically, SSA is a continent mainly still awaiting significant industrialisation yet plagued by food insecurity. Despite the prevalence of food insecurities in SSA, a smaller portion of the literature focused on nutritional or livelihood contributions of fish to diets. This shows that the literature is focused on the dangers of fish consumption rather than its positive contributions to wellbeing, which may, at least partly, explain why fish are often forgotten in food security policy (Bennett et al., 2021). Among the articles focusing on nutritional or livelihood contributions, eleven themes resulted: (1) fish versus other animal source foods, (2) fish consumer science, (3) fish consumption rates, (4) nutritional value of fish in diets, (5) human health outcomes from fish consumption, (6) perceptions of fish as food, (7) fish acquisition, (8) livelihoods, (9) gender, (10) policy and data, and (11) supply demand.

Considering these themes, this review identified two gaps in the literature. Firstly, more research considering the complex role of fish in food systems is needed. This review found that most literature focuses on fish from either fisheries or aquaculture, with only a small portion considering the integrated contribution of both (e.g., Kaminski et al., 2024). Of articles on fisheries, very few examined the role of fish in food security within their methodology. This percentage was even less for articles on aquaculture topics. Similarly, most articles discussing the nutritional or dietary contributions of fish focused on consumption only, often without considering the source of the fish, despite that the nutritional composition of fish can vary by source. Despite the widespread

acknowledgement of the micro-nutritional importance of fish, this review found only three articles considered micronutrient intake from different fish species and production systems (Okonji & Anoma, 2007; Sanon et al., 2021; Kaminski et al., 2022). Future research focused on the contribution of fish to food security could be enhanced by considering how different production methods influence nutritional or livelihood outcomes in a variety of SSA contexts; for instance, wild and farmed fish have different nutritional contribution in Bangladesh (Bogard et al., 2017), although this has not been studied in Africa. This approach is important for developing food fish systems that support food security (Tezzo et al., 2020). In addition, very few articles explored the indirect role of fish production in supporting food security through livelihoods; thus, more research is required on how engagement in fish production (both fisheries and aquaculture) can support food security through income-generating and subsistence activities. This thesis will contribute towards filling this gap.

Secondly, more research into socioeconomic and nutrition-sensitive aquaculture production and development that are synergistic with inland fisheries is needed. Currently, literature on fish production is unequally weighted toward fisheries, particularly ecology and stock assessments and fish biology topics. The number of articles on fisheries was over four times the number on aquaculture, which mismatches production statistics: as of 2020, freshwater aquaculture in Africa contributed approximately 1.9 million tonnes compared to 3.21 million tonnes from inland capture fisheries, where the latter may be underestimated due to ‘hidden’ (i.e., unmonitored and unaccounted) harvests (FAO, 2022; FAO, 2023). Yet, if aquaculture is a development priority to improve fish consumption (Chan et al., 2019), research to guide its sustainable development is necessary (Weitzman & Filgueira, 2020; Turon et al., 2005; Campanati et al., 2021; Nyamweya et al., 2022). The literature generally frames fish production as via either aquaculture or fisheries; however, scenarios for fish production from across the aquaculture-fisheries continuum are discussed in Kaminski et al. (2022) and Sanon et al. (2021). In aquaculture, seed is sourced from self-recruiting fisheries; in the latter, fisheries are stocked with cultured seed. Nutrition-sensitive aquaculture development strategies should consider synergies between aquaculture and fisheries (Thilsted et al., 2016).

This work has identified the need for several areas of future research on the role of freshwater fish in food security for SSA. Generally, more studies on fish consumption in SSA to provide clarity on where and why fish consumption happens is required. Considering the small quantity of these types of articles identified by this literature review and the wide variation in fish consumption patterns across SSA, regionally focused research is warranted. Literature on socioeconomic and nutrition-sensitive food-fish systems, examining both aquaculture and fisheries, is needed. Aquaculture may need to be located near areas with a high fish demand, which may likely coincide with fisheries, and its synergies and trade-off should be understood to maximise benefits and minimize negative externalities. Synergistic solutions are paramount considering that small pelagic fish – identified as

critical nutritionally for the poor and geographically for improved access when dried – are unlikely to be supplied through aquaculture. The different drivers for the exploitation of small pelagic versus culturing of larger fish should be examined to avoid marginalisation of vulnerable people. De Bruyn et al. (2021) summarises the need, calling for "context-specific assessments to understand... the different trajectories and trade-offs [between fisheries] with aquaculture". Furthermore, an understanding of how policy conditions affect the contribution of fish to diets in the region are also needed (De Bruyn et al., 2021).

2.4 Conclusion

This review found that the role of fish in supporting food security in SSA is both direct through consumption and indirect through livelihoods provisioning, although the latter may be more important. Furthermore, regional variations in consumption and livelihoods provisioning are apparent; thus, more regionally focused research is recommended. Few studies considered fish production from across the aquaculture-fisheries continuum, and the remainder framed fisheries and aquaculture as a dichotomy. The literature needs more research that considers the various ways that fish are being produced and the seasonal, nutritional, and economic effects that these joint systems have on people's food security. Additionally, more literature on socioeconomic and nutrition-sensitive food-fish systems, considering synergies between aquaculture and fisheries, is required to better evidence and support food security development strategies and effective policy development. Therefore, this thesis will explore direct versus indirect contributions of fish (from both fisheries and aquaculture) to food security in a geographically-focused study area. It will aim to consider nutritional and economic effects and the role of fish contextualised within the broader food system to understand its relative relevance.

Chapter 3: “Historical and geographical perspectives on Lake Victoria – a study area description”

The first literature review was essential to understand the state of the art for food security and food fish value chains in SSA broadly; this section provides an in-depth history of our specific study area Lake Victoria, its fisheries, and its littoral communities through a systematic literature review. The aim of this review was to describe the current understanding of Lake Victoria and elements influencing its food security since the introduction of Nile perch. Lake Victoria is the largest freshwater lake in SSA and the second largest globally. Currently, it is internationally regulated, falling under Kenyan (6%), Tanzanian (51%), and Ugandan (43%) jurisdiction.

3.1 Methods

Following the methods described in Chapter 2, This review (1) identified, (2) compiled, (3) coded and categorised, and (4) summarised literature that investigated Lake Victoria, its food fish system, and its littoral communities.

(1) Identifying: Using the online search engines, all potentially relevant articles were identified. The search was conducted on 3 March 2023 using the electronic databases Web of Science and Scopus. The search was limited to articles between 1990 and 2023. The string of search terms was “*Lake Victoria*” AND (*fisheries OR aquaculture*) AND (*Uganda OR Kenya OR Tanzania*). The titles and abstracts of the search results for both searches were retained for review in a Microsoft Excel file (Version 16.73, Microsoft Corporation, 2018).

(2) Compiling: The data was downloaded into an Excel file, which included authors, year of publication, title, total citation count, journal, and abstract. Duplicates were removed and articles that did not focus on Lake Victoria were excluded.

(3) Coded & Categorised: The titles and abstracts were reviewed to categorise each article.

(4) Summarised: A large portion of the literature focused on fish biology and genetics, which was not reviewed. Some articles studied food safety and heavy metal poisoning but were also not reviewed. All other articles were reviewed in-depth and summarised.

3.2 Results

Out of the 390 included articles, 46 were unavailable for in-dept review because they were not available for online downloading nor through the University of Stirling’s library system. The main category was indeed littoral human communities, followed by governance topics, as shown in Figure 4, where longer bars indicate more article within each category on the y-axis. The most prominent sub-category within littoral communities was disease (e.g., HIV, malaria), followed by various aspects of household livelihoods topics. Based on the available articles, the following text will

describe the recent history of Lake Victoria, its fisheries, and its littoral communities. Many of the articles were of poor quality (for example, lacking peer-review), and unpublished literature and information conversations may provide more reliable information. Particularly literature from the 1990s were written by and from the perspective of European-born expatriates and contained conflicting details (e.g., dates and locations of Nile perch introduction, indigenous value of smaller fish). To acknowledge history from both the indigenous and academic knowledge-base, this result section includes details recounted by my key informants despite a lack of published literature. Additionally, a timeline is included to support the text below (Figure 5).

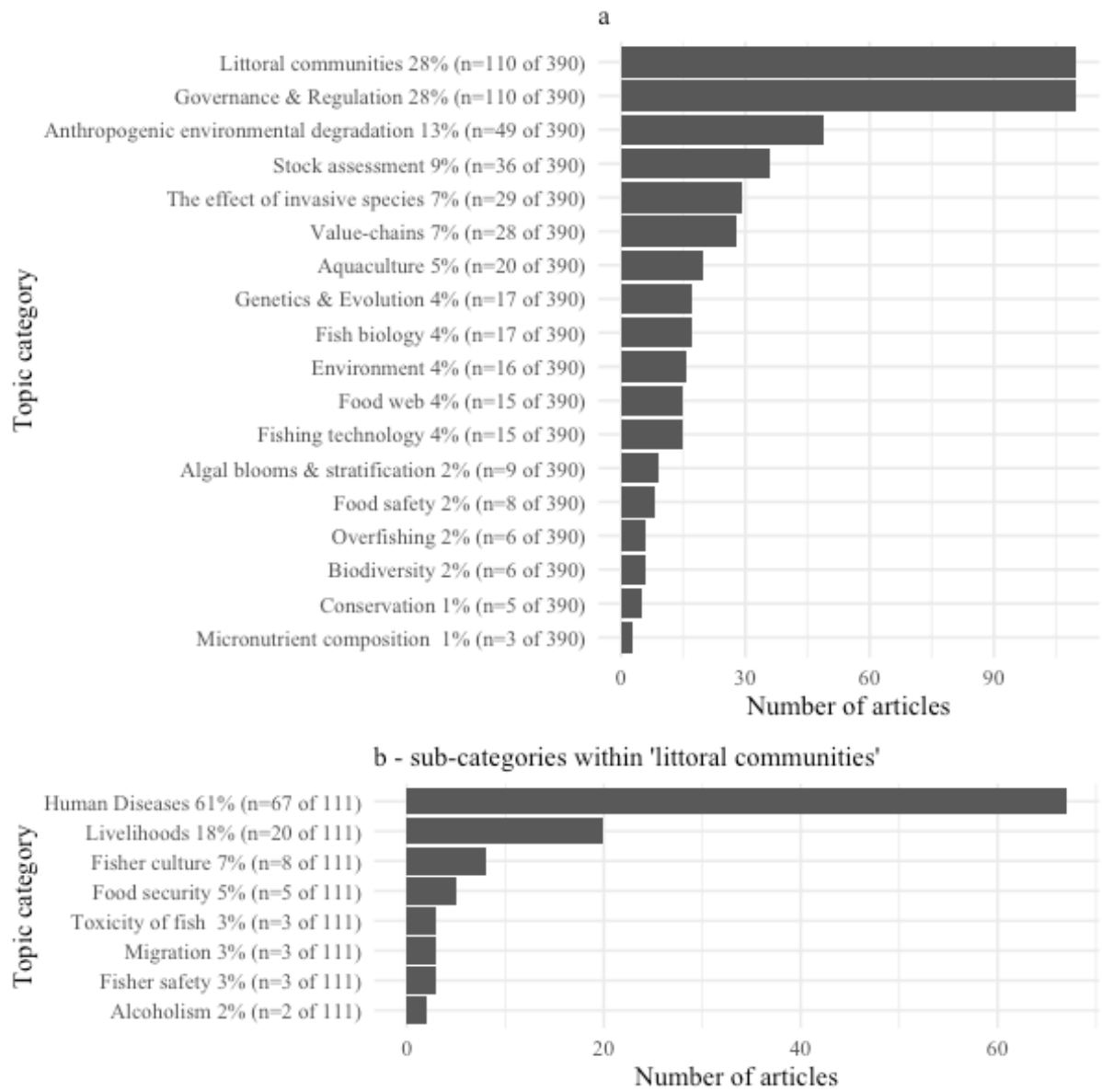


Figure 4: Categories resulting from descriptive coding of included articles' titles and abstracts, for articles considering Lake Victoria. Figure 'b' shows the sub-categories with the 'littoral communities' category.

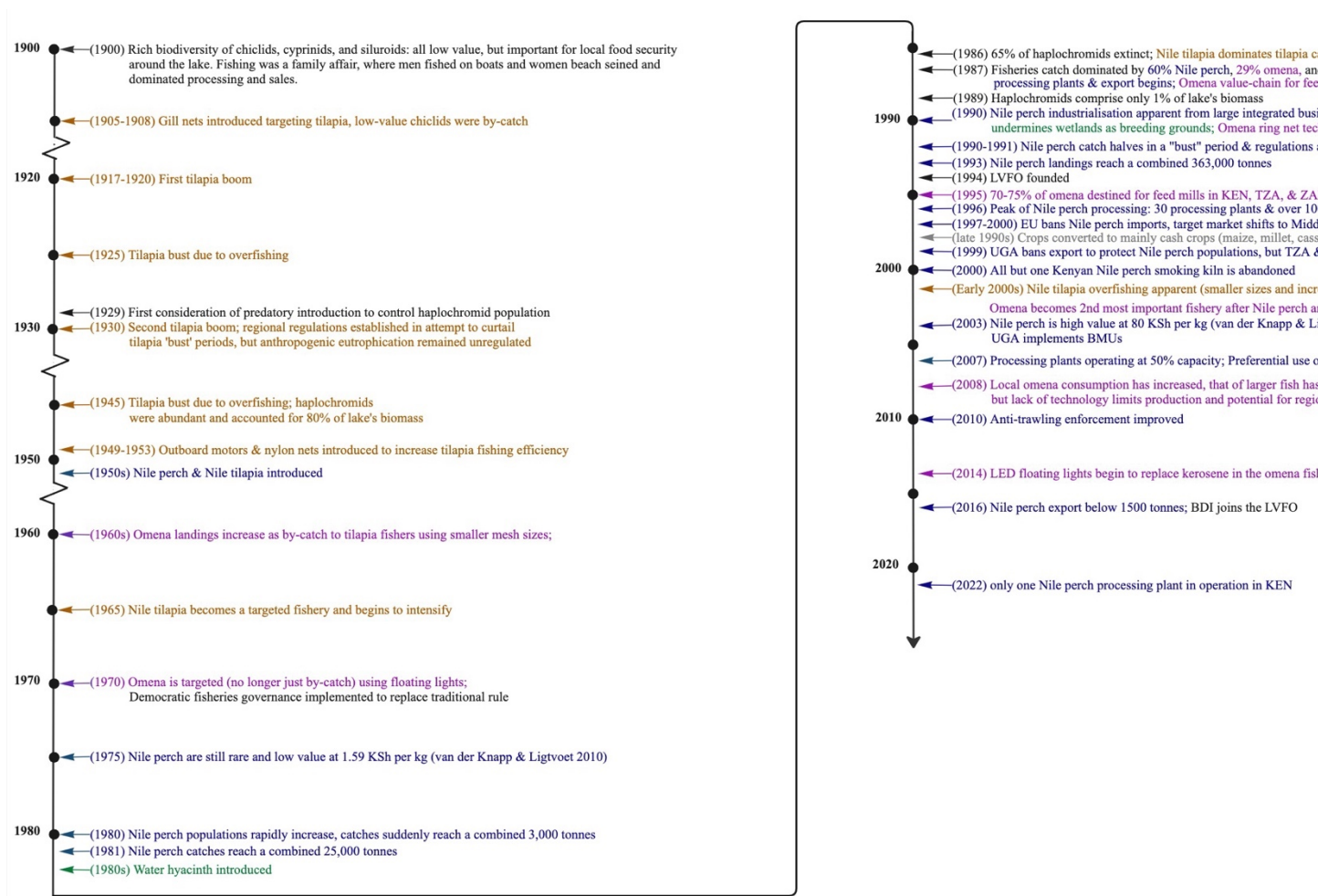


Figure 5: Timeline of the history of Lake Victoria and its fisheries from 1900 to 2022, based on the analysis of the literature.

3.2.1 Before the introduction of Nile perch

In the early 1900s, Lake Victoria had rich biodiversity due to its array of native cichlids (*haplochromines*, *tilapias*), cyprinids (*Earbus*, *Labeo*, *Rastrineobola*), and siluroids (*Bagrus*, *Clarias*, *Synodonis*, *Schilbe*; (Achieng, 1990). Its tilapias ('ngege' in Swahili/Duluo, mainly *Oreochromis variabilis* and *O. esculentus*), carps ('ningu' in Duluo, *Labeo spp.*), Bagrid catfish ('seu' in Duluo, 'hongwe' in Tanzania, *Bagrus spp.*), Clarias catfish ('mumi' in Duluo, *Clarius spp.*), and lungfish ('komongo' in Duluo, *Protopterus spp.*) were likely mainstays of local food security (Gibbon, 1997a). Its array of haplochromid species ('furu' in Swahili, 'fulu' in Duluo, *haplochromid spp.*), and, to a lesser extent, a small silver cyprinid ('omena' in Kenya, 'mukene' in Luganda, 'dagaa' in Swahili; *Rastrineobola argentea*) were also species that were consumed locally (Achieng, 1990; Gibbon, 1997a; Witte et al., 1999). Key informants from my interviews reflect that omena was less prominent and less relevant to food security at that time. While tilapia and other larger fish were targeted using hook and lines from boats, haplochromids and omena were primarily caught by wading women using scooping baskets that were cooked mainly in soups (Okedi, 1981; Ligvoet et al., 1995). These women fished opportunistically throughout the year; fishing from boats was generally seasonal and part-time (Gibbon, 1997a). Fisheries, although legally open-source, were regulated locally by traditional governance systems (e.g., chiefdoms), stipulating and enforcing restrictions around fishing access (Jansen et al., 2000). Village chiefs and elders had controlled fisheries access and managed fisheries resources by inheritance (Etiegni et al., 2019).

When gill nets were introduced from Europe in 1905-1908, the fisheries industry quickly developed, accounting for an estimated 25% of Africa's inland catch (Achieng, 1990; Ogutu-Ohwayo, 1990; Balirwa, 1995; Gibbon, 1997a). Tilapias were the main targeted species, although the bulk of catch was haplochromid species (Gibbon, 1997a). Resulting from the intensification of the fishery, commercial fishing urban centres and road networks developed (Balirwa, 1992; Gibbon, 1997a). These fishing technology and infrastructure improvements led to the first tilapia boom in 1917-1920, where up to 5 million dried or smoked tilapia pieces were shipped by rail regionally (Gibbon, 1997a). By 1920s tilapia stock had significantly declined; because the decline was attributed to overfishing, regional fishing regulations were introduced by colonists in the 1930s, who viewed the Lake's tilapia as an important food source (although haplochromids and other species were largely ignored) and recreational fishery (Balirwa, 1992). However, declining fish stock was also due to poor water quality (cyanobacterial and blue-green algal blooms) caused by increasing deforestation and run-off occurring in the lake watershed, yet these remained largely unregulated (Balirwa, 1995).

Tilapias continued a 'boom and bust' cycle. Tilapias boomed again in 1930 (Gibbon, 1997a). The subsequent 1945 crash was later blamed on the intensification of fishing (particularly in Kenya; Gibbon, 1997a; Jansen et al., 2000). Fisheries regulation was first described in national-level governance in the 1945 Laws of Kenya to establish fishing licenses and manage overfishing. While

regulations on net size and gear use had been established in the 1945 laws, no enforcement was possible due to a lack of governance resources (Gibbon, 1997a). Additionally, these laws were likely intended to prioritise fisheries development and monetisation, as part of British colonial development strategies (Gibbon, 1997a). Shortly thereafter in 1949-1953, outboard motors and nylon nets were introduced to improve fishing efficiency (Gibbon, 1997a; Jansen et al., 2000). This caused the near extinction of certain species, for example *Oreochromis variabilis* (Maithya et al., 2012). In contrast to tilapias, other cichlids remained abundant: Lake Victoria's cichlids accounted for 5% of the world's known freshwater fish species and 85% of the lake's biomass (Gophen et al., 1995). Although key informants reflect that haplochromids were eaten locally, both for subsistence and medicinal purposes, academics and government considered them low value and "undesirable" (Worthington & Lowe-McConnell, 1994). Colonial scientists dominated the research, either exploring taxonomy or asserting agendas to increase value and/or productivity. As early as 1929, researchers and policy-makers began discussing the introduction of a predator species to convert haplochromids and cichlids into an 'edible fish' (ignoring their contribution to local food security); theoretically, this would support food security and attract recreational fishing tourism (Figure 6; Achieng, 1990; Worthington & Lowe-McConnell, 1994; Balirwa, 1995; Gibbon, 1997a; Pringle, 2005a).



Figure 6: 2009 Largest Nile perch (112.94 kg and 208 centimetres) caught by Tim Smith¹.

It is unclear from the literature how Kenyan, Tanzanian, and Ugandan independence in 1960-1964 affected fisheries policies or their implementation; however, exploiting Lake Victoria's fisheries for

¹ This photo was under a Creative Commons license and accessed at: <https://bigfishesoftheworld.blogspot.com/>

nutritional and economic purposes was advised (e.g., Rhodes, 1966). In 1970, a democratic process was installed to elect beach leaders, intending to replace inheritable positions and Chieftdom rule (Etiegni et al., 2019). Until the mid 1970s, fisheries were accessed exclusively by approximately 50,000 small-scale fishers, using 12,000 dug-out owner-operated canoes (Jansen et al., 2000). Fishing was a family business: male family members fished while female family members engaged in processing and sales (Witte et al., 1999). At the same time, small-scale women operators dominated the processing and trade sector and very few wholesalers existed; thus, it was unlike other fisheries where wholesalers had economic control over fishers (Jansen et al., 2000). While littoral communities (predominantly of the Luo ethnic group) provided the main human capacity source for fishing, they also farmed and herded livestock (Geheb & Binns, 1997). Fishing and farming were complimentary activities (Geheb & Binns, 1997). Most littoral communities' animal source food consumption was fish (Jansen et al., 2000).

3.2.2 The introduction of Nile perch and resulting ecological consequences

Nile perch (*Lates niloticus*) and Nile tilapia (*Oreochromis niloticus*) were introduced to Lake Victoria sometime in the 1950s (Achieng, 1990; Gophen et al., 1995; Pringle, 2005a): the introduction date is contested within literature. In two informal conversations during fieldwork, experts in Lake Victoria's fisheries believe that these fishes were introduced at various points around the lake, likely driven by colonial interests and directives. While some government officials recall dumping barrels of Nile perch into the lake, other stories involved people sneaking in Nile perch, stored in buckets transported in the back of their vehicle. Due to the lack of evidence, assigning a responsible party for the Nile perch introduction is impossible. Regardless of whoever was responsible, Nile perch and Nile tilapia populations thrived and the environmental impacts were immense (Nyamweya et al., 2016a).

As voracious predators, Nile perch and Nile tilapia significantly altered the ecosystem through trophic interactions (Achieng, 1990; Bruton, 1990; Worthington & Lowe-McConnell, 1994; Natugonza et al., 2016). While Nile perch populations initially remained low, they exploded in the 1980s (Witte & Goudswaard, 1999). Haplochromids became the principal and preferred prey for Nile perch (Worthington & Lowe-McConnell, 1994). Between Nile perch predation and haplochromid overfishing for local consumption (Goudswaard et al., 2008), over 65% (200 of over 300 endemic species) of haplochromid species went extinct between 1982 and 1986 (Worthington & Lowe-McConnell, 1994). Haplochromid stocks declined from 80% pre-introduction to less than 1% of the lake's biomass by 1989 (Achieng, 1990).

While many authors inculpate the introduction of Nile perch for haplochromid collapse (Achieng, 1990; Worthington & Lowe-McConnell, 1994; Gibbon, 1997a), others evidence that haplochromid collapse began before the introduction of Nile perch (Witte et al., 1999; Ngoepe et al., 2024). Indeed, some contend that haplochromid collapse enabled Nile perch proliferation (van Zwieten et al., 2016).

They argue that Nile perch juveniles would have been consumed by haplochromids, which would have prevented Nile perch establishment (van Zwieten et al., 2016). This also provides a theory for why Nile perch populations failed to increase until over 20 years after their introduction: haplochromid populations were still creating significant predation pressure on Nile perch juveniles (van Zwieten et al., 2016). Unfortunately, the timeline is difficult to triangulate with fisheries monitoring data because it began only in 1970 after ecological alterations were well underway (Ngoepe et al., 2024). The large percentage (40%) of other piscivorous fishes in the lake – including catfish populations (*Clarias gariepinus*, *Bagrus docmac*, *Schilbe intermedius*, *Xenoclarias eupogon*, *Synodontis victoriae*, *S. afrofischeri*) and lungfish (*Protopterus aethiopicus*) that previously preyed on haplochromids – became prey to and by-catch of Nile perch and their populations also declined (Ogutu-Ohwayo, 1990; Worthington & Lowe-McConnell, 1994; Frans Witte, 1997; Goudswaard & Witte, 1997; Goudswaard et al., 2002b). Overfishing of these other piscivorous fish species was also attributed to their decline (Achieng, 1990). While these species populations failed to recover (Outa et al., 2020), Nile perch persevered due to its flexible feeding habits: after exhausting haplochromid populations, adult Nile perch preyed on omena and juvenile Nile perch, while juvenile Nile perch fed on ochonga (*Caridinia nilotica*) and insects (Katunzi et al., 2006; Cornelissen et al., 2018; Agembe et al., 2019). Yet, Nile perch did not affect omena (*Rastrineobola argentea*) stocks because omena lived at different depths and tolerated lower oxygen levels than Nile perch, thus were somewhat protected (Gibbon, 1997a; Campbell et al., 2003; Nyamweya et al., 2016a). Likewise, Nile perch did not affect Nile tilapia stocks (Gibbon, 1997a; Campbell et al., 2003; Nyamweya et al., 2016a). While Nile perch did opportunistically prey on Nile tilapia, tilapia preferred shallow waters whereas Nile perch preferred deeper waters (Goudswaard et al., 2002a). Without significant predation and low competition with other tilapia species that were overfished, Nile tilapia gradually replaced native tilapia species through hybridisation, overcrowding, food competition, and its more generalists feeding habits (Bruton, 1990; Balirwa, 1992; Worthington & Lowe-McConnell, 1994; Goudswaard et al., 2002a). While native tilapias failed to contribute significant economic contributions and never recovered from overfishing in the early 1900s, Nile tilapia had become a commercial fishery by 1965 (Balirwa, 1992). By 1986, Nile tilapia dominated tilapia catches (Goudswaard et al., 2002a).

The decreasing haplochromid population also affected lower trophic levels as early as the 1960s (Witte et al., 1999). As a group of species, haplochromids were known for their genetic adaptability within the trophic web, feeding on a variety of lower-trophic level foods (omena, algae, zooplankton, insect larvae, bacteria, molluscs, shrimps; Bruton, 1990; Worthington & Lowe-McConnell, 1994). With haplochromid collapse, these lower-level foods increased, apart from zooplankton: omena biomass increased in the absence of their haplochromid predators and because they no longer competed with haplochromids for zooplankton (Gophen et al., 1995; Ojwang et al., 2004; Nyamweya et al., 2016a). The increase in omena led to fishing intensification, with the targeting of omena on boats using floating lights in the 1960s (Okedi, 1986; Ligetvoet et al., 1995). Detritus accumulated:

while nearshore ochonga (*C. nilotica*) are detritus consumers, most of the ochonga biomass is in offshore populations, which are also zooplanktonavores (Ignatow et al., 1996). Thus, while zooplankton levels declined under omena and ochonga predation (Gophen et al., 1995; Ojwang et al., 2004; Nyamweya et al., 2016a), other lower-trophic level foods (algae, bacteria, detritus) undesired by omena and ochonga thrived (Bruton, 1990; Worthington & Lowe-McConnell, 1994; Gophen et al., 1995). In the absence of their main predators, algae, phytoplankton and detritus increased, and their decomposition abetted longer-term eutrophication and deoxygenation (Bruton, 1990; Worthington & Lowe-McConnell, 1994; Gophen et al., 1995).

Eutrophication of the lake also added stress to fisheries populations and had several contributors besides algae, phytoplankton, and detritus. Deforestation (particularly of wetlands and papyrus; Balirwa, 1995; Kiwango & Wolanski, 2008) coupled with increased agricultural and land-based industrial runoff from cities around the lake (e.g., Kisumu in Kenya) also contributed to eutrophication and decline of breeding grounds for native fishes, which worsened over time (Gophen et al., 1995; Goudswaard et al., 2002b; Hecky et al., 2010; Sitoki et al., 2010; Nyamweya et al., 2016a; Nyamweya et al., 2016b; Kundu et al., 2017). Eutrophic conditions and algal blooms degraded water quality with repercussions for those relying on the lake for drinking water (Roegner et al., 2020). Lake Victoria is stratified, with warmer, oxygen-rich surface waters overlying colder, oxygen poor deeper waters. Storm conditions cause lake stratification turnover annually between June and August (Ochumba, 1988, 1990; Nyamweya et al., 2016b; Woodhams et al., 2019). Lake turnovers still occur today, where oxygen poor lower layers upwell, causing anoxic surface conditions (Marshall et al., 2013). Eutrophication has led to several mass fish mortality events in Lake Victoria known as ‘fish kills’ (Geheb & Binns, 1997). While Nile perch demonstrate considerable tolerance to water quality (for instance, changes to water temperature; Nyboer & Chapman, 2017), lake turnover was a significant threat to Nile perch populations because it causes anoxic conditions (Goudswaard et al., 2011; Nyamweya et al., 2016b). Eutrophic conditions and lake stratification (‘oxycline’) had increased over time (Worthington & Lowe-McConnell, 1994).

Fisheries populations of all species were further challenged from damages to littoral wetlands. Wetlands were important because water flushing protected them from anoxic conditions elsewhere in the lake, providing protection and refuge for larval fish, tilapias, and ochonga (*C. nilotica*; Balirwa, 1995; Mnaya & Wolanski, 2002); however, introduction of water hyacinth (*Eichhornia crassipes*) in the 1980s via the Kagera River from Rwanda and their rapid propagation by the 1990s led to reduced oxygen levels, increased sedimentation, and altered water quality in these wetlands (Balirwa, 1995; Williams et al., 2005). Hyacinths were particularly damaging to the omena fishery (Gibbon, 1997a) and later, the Nile tilapia industry (Ongore et al., 2018). Hyacinths caused a host of other issues, including disrupting fisheries activities, providing breeding ground for human disease vectors, impacting on biodiversity, and contributing to eutrophication by blocking light (Opande et al., 2004; Kateregga & Sterner, 2007; Kateregga & Sterner, 2009; Hecky et al., 2010; Ongore et al., 2018).

Intermittent hyacinth mitigation strategies that were temporarily effective coupled with eutrophication patterns from anthropogenic run-off and pollution resulted in a hyacinth ‘boom and bust’ cycle (Balirwa, 2007; Sitoki et al., 2010; Ongore et al., 2018).

Fisheries stock assessments also demonstrated ‘boom and bust’ cycles (Figure 7). These figures may be underreported, as fishers and processing plants often failed to report accurate numbers for tax-avoidance purposes (Gibbon, 1997a). ‘Fulu’ refers to haplochromid species and ‘ochonga’ refers to a shrimp (*Caridina nilotica*) often caught alongside omena, which decreased slightly over time. Ochonga fisheries were monitored beginning in 2015, previously having been included in ‘omena’ production quantities. ‘Aquaculture’ production was unstable but neutral trending over time, consisting of mainly tilapia, with some catfish (annual statistics on each cultured species were not provided in national reports). Annual data on the number of fishers on the lake was sporadic and inconsistent across government reports.

Nile perch survived the near eradication of haplochromids due to its flexible feeding habits (Ogutu-Ohwayo, 1990). As haplochromid stocks reduced, larger Nile perch shifted predation to pelagics, including juvenile Nile perch, tilapias, and omena (Ogutu-Ohwayo, 1990; Oguto-Ohwayo, 2004). While adult Nile perch cannibalism of juveniles decreased recruitment to the adult stock, its high reproductive rate ensured its population’s survival (Ogutu-Ohwayo, 1990). Meanwhile, juvenile Nile perch predation shifted to ochonga and insect larvae (Ogutu-Ohwayo, 1990; Branstrator et al., 2003; Agembe et al., 2019). Ochonga was a significant forage source for all fish species (Campbell et al., 2003; Budeba & Cowx, 2007; Ngupula & Mlaponi, 2010; Cornelissen et al., 2018). With its high reproductive rate, ochonga production was estimated at over 10 times the fishery yield of the Lake (Ignatow et al., 1996; Budeba & Cowx, 2007; Ngupula & Mlaponi, 2010). In contrast, tilapias were less resistant to Nile perch predation. Nile perch predation on juvenile tilapias was the main cause for tilapia decline, although fishing pressure also contributed (Mugisha & Ddumba, 2007). Nile tilapia was the only tilapia that seemed resistant to Nile perch predation (Balirwa, 1992). Some authors warned that overfishing of Nile perch would lead to Nile tilapia becoming the predominant fishery, which was concerning due to its lower economic value (Njiru et al., 2008b).

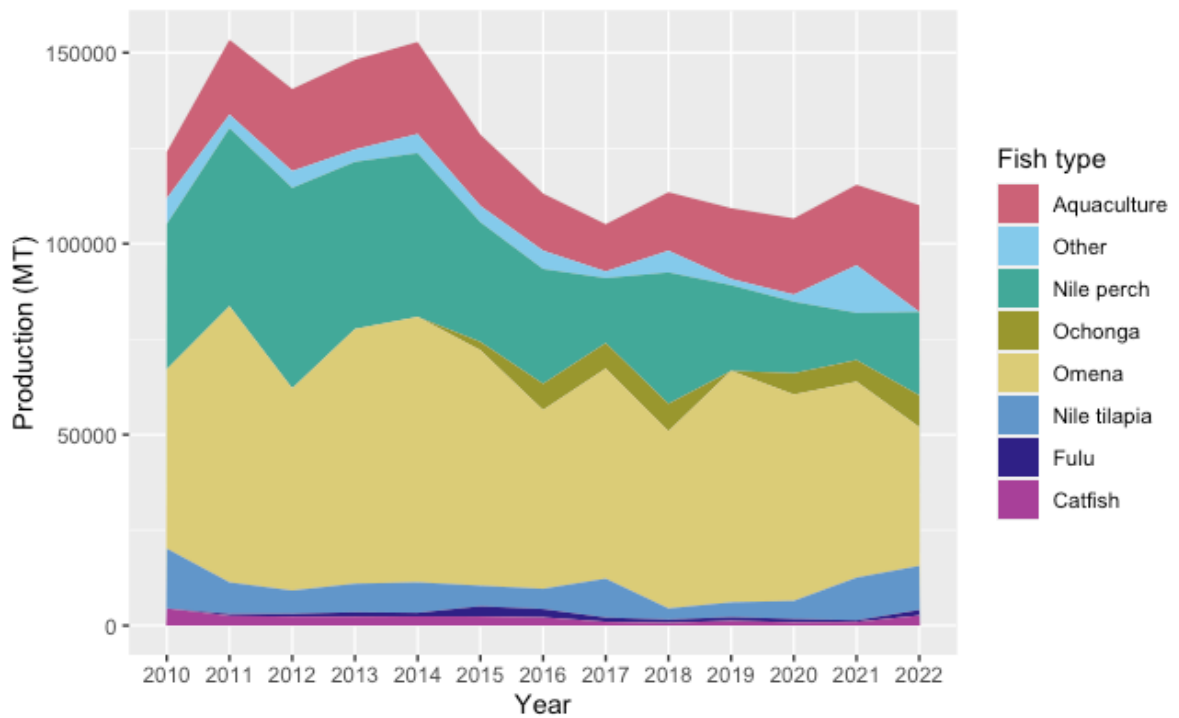


Figure 7: Cumulative landings by species for the years 2010 through 2022 using data from KeFS (2022). Landings are stacked, reflecting total production quantities. See Schubert et al., (2022) for catch estimations for 1950 through 2010.

Despite its opportunistic and flexible feeding habits, Nile perch populations declined due to a combination of fishing pressure (Geheb & Binns, 1997; Jansen et al., 2000), eutrophication (Kolding et al., 2008; Hecky et al., 2010), cyclical lake turnover events (Geheb & Binns, 1997; Goudswaard et al., 2011; Nyamweya et al., 2016b), and cannibalism of its young (Ogutu-Ohwayo, 1990). Meanwhile, some original haplochromid species avoided Nile perch predation in shallow waters (Achieng, 1990), and their stocks increased during Nile perch bust periods (Njiru et al., 2008b; Kische-Machumu et al., 2015). Once some haplochromid populations re-established, Nile perch shifted their predation back to haplochromids, thus restarting the cycle (Awiti, 2011; Kische-Machumu et al., 2015). Ochonga and native tilapia population patterns aligned with those of Nile perch. Ochonga and native tilapia populations increased as Nile perch preyed on haplochromids during haplochromid resurgence; ochonga and native tilapia populations decreased during periods of haplochromid near disappearance when the Nile perch population had a higher proportion of juveniles, increasing predation on ochonga and juvenile tilapias (Ngupula & Mlaponi, 2010; Cornelissen et al., 2018; Agembe et al., 2019).

With these ecological changes, Lake Victoria's rich and biodiverse fisheries became replaced by four main species: Nile perch, Nile tilapia, omena (*Rastrineobola argentea*), and ochonga (*Caridina nilotica*; Achieng, 1990; Natugonza et al., 2016). Locals lamented the loss of 'sweet' tasting fish (Pringle, 2005b), though it's unclear from the literature whether they were referring to haplochromids, native tilapias, catfish or lungfish. Some authors argued that biodiversity was not a prerequisite for fisheries productivity (Lévêque, 1995). Indeed, while haplochromid and native

tilapia biodiversity severely declined, total fish landings increased five-fold (Worthington & Lowe-McConnell, 1994). In the absence of its haplochromid predators, omena stock increased and fishers began targeting them using floating lights (Worthington & Lowe-McConnell, 1994). By 1987, Lake Victoria's fisheries catch was composed of 60% Nile perch (68,000 tonnes), 29% omena (33,000 tonnes), and 9% tilapias (10,000; Achieng, 1990).

Lake Victoria's Nile perch fishery became one of the most productive globally and was studied extensively for the transformation of its ecology and trophic web (Johnson, 2010). Drivers of the 'boom and bust' nature of Lake Victoria's fisheries was debated. Some argued it was due to anthropogenic overfishing (Geheb & Binns, 1997; Jansen et al., 2000), whereas others argued eutrophication was a larger threat to fish stocks (Kolding et al., 2008; Hecky et al., 2010). Regardless, its environmental impacts were irreversible, and led to significant and sustained biodiversity loss (van der Knapp, 2013; Natugonza et al., 2016). An export market for ornamentals also eventually developed, further threatening the lake's biodiversity (van der Knapp, 2013).

To address these effects, several strategies were employed. Biologists attempted captive propagation of haplochromid species (Reid, 1990; Bruton, 1990). Additionally, biologists urged for the closure of the haplochromid fishery (Bruton, 1990). It is unclear if these initiatives were successful or implemented at scale. Considering that haplochromid and native tilapia species suffer ongoing decline suggests these initiatives were either ineffective or unsuccessfully implemented (Outa et al., 2020). Implementation was likely limited considering the lake's size and its lack of international coordination. Regardless, the loss of genetic and trophic biodiversity has been considered irreversible (Bruton, 1990; Natugonza et al., 2016). Another strategy was reducing Nile perch population through fishing effort (Bruton, 1990; Christensen, 1996), which eventually led to drastic consequences and opportunities for Lake Victoria, as discussed in the following sections.

3.2.3 Nile perch fishery and value-chain development

The social and economic impacts of Nile perch were slow to evolve, then developed rapidly (Witte et al., 1999). Upon its introduction, Nile perch was initially rejected by littoral communities due to taboos (e.g., myths including "it feeds on humans", "large animals are inedible"; Achieng, 1990; Riedmiller, 1994; Witte et al., 1999). Furthermore, it was difficult to preserve through sun drying and cook using traditional methods (Achieng, 1990; Riedmiller, 1994; Witte et al., 1999). Fishers (mainly male) and fish traders (mainly female) faced exploding Nile perch populations with few customers (Achieng, 1990). Fishers switched to finer (illegal) mesh sizes in attempt to target tilapia (Witte et al., 1999). To support the Nile perch industry development, the government encouraged regulated Nile perch fishing – using large mesh gill nets for reproductive size fish and beach seine nets for juveniles – to control populations as an haplochromid conservation strategy (Kitchell et al., 1997; Ogutu-Ohwayo, 1999; Raymond et al., 2019). Indeed, heavy fishing did decrease populations, allowing for a resurgence in haplochromid and other species across the trophic web (Witte et al.,

2007; Awiti, 2011). Gradual acclamation fuelled by government propaganda encouraged its consumption, including recipes and cooking lessons (Pringle, 2005b). With a lack of other fishes to eat and inventive cooking methods (frying, smoking, and filleting), locals began eating Nile perch (Achieng, 1990). The need for firewood to fry and smoke this oily fish contributed to local deforestation (Witte et al., 1999).

Thereafter, fishers began targeting Nile perch. Kenyan Nile perch fishers caught 1,000 tonnes in 1978, 23,000 tonnes in 1981, and 123,000 tonnes in 1991 (Jansen et al., 2000). Uganda and Tanzania followed suit: each caught less than 1,000 tonnes in 1981 but reached 41,000 tonnes in Uganda and 82,000 tonnes in Tanzania by 1986. By 1986, 84% of fishers were targeting Nile perch and regional trade systems between the lakeshore and urban centres were operational (Gibbon, 1997a). In 1993, all three countries caught a combined 363,000 tonnes of Nile perch. Fishers, who had used increasingly finer mesh nets to target the failing tilapia fishery after the 1945 bust, switched back to using large mesh-size nets to target Nile perch instead (Achieng, 1990). The most popular fishing methods were gill nets, beach seine nets and long lines and hooks (Gibbon, 1997a). Hooks became increasingly popular, and fishers started using mainly juvenile catfish, but also haplochromids and omena in smaller quantities as bait, exacerbating pressure on these fisheries (Mkumbo & Mlaponi, 2007).

Rapid fishing industry intensification was driven by development of an export-oriented value-chain and drastically altered the littoral economy. In 1987, high yields attracted a handful of new actors with foreign investment, who set up processing plants to provide fillets to wealthier classes regionally and internationally (Achieng, 1990; Ogutu-Ohwayo, 1990; Abila & Jansen, 1997; Gibbon, 1997a; Jansen et al., 2000; Beuving, 2010). Nile perch became associated with a higher social status: as a high-value export commodity, consumption of Nile perch was ‘in vogue’ (Pringle, 2005b). The financial and social value of Nile perch strengthened Nile perch fishers’ initiative (Pringle, 2005b). Farming was increasingly neglected as littoral communities focused their livelihoods on the lucrative Nile perch fishery (Pringle, 2005b). By the late 1990s, the main crops were maize, millet, and cassava, although production was limited by poor rainfall patterns, limited agricultural technology, and plot division during inheritance (Geheb & Binns, 1997). By and large, agricultural investment dwindled because daily fishing income was preferred over seasonal and relatively unreliable agricultural income (Mwakubo et al., 2007).

Despite regulations, the Nile perch industry’s rapid expansion was largely unaffected. The first official Fisheries Act was implemented in 1989; the Act stipulated top-down governance, but local leaders used the Act “in combination with customary laws to manage the fishery” (Etiegni et al., 2019; Etiegni et al., 2020). Lake management was disjointed and lacked regional coordination (Njiru et al., 2018). Despite recommendations for an ecosystem-based approach to managing anthropogenic eutrophication and pollution (Kolding et al., 2008; Sitoki et al., 2010; Badamasi et al., 2019), most regulations focused on managing overfishing (Njiru et al., 2014). Some beach cooperatives received

up to 18 tonnes per day (Riedmiller, 1994) and plants processing around 4000 tonnes annually (Gibbon, 1997a). By 1990, industrialisation was apparent, with large integrated business owners and aggregators bringing scales to the beach, sourcing fish from around the lake, and trucking fish to processing plants (Gibbon, 1997a; Jansen et al., 2000). By 1996, around 30 processing plants peppered the Kenyan lakeshores alone and over 75% of catch was directed to the export trade (Gibbon, 1997a).

While most Nile perch was caught in Kenya and consumed regionally, an export market also burgeoned when processing plants were established. Salted and dried Nile perch was exported to Zaire (later, the Democratic Republic of Congo (DRC)); frozen whole and filleted perch was sent to European and Middle Eastern markets (Abila & Jansen, 1997; Gibbon, 1997a; Lombardi & Anderson, 1998; van der Knapp & Ligtvoet, 2010; van der Knapp, 2013). Two main export markets (one regional and another international) resulted in two value-chain streams for Nile perch processing and trade. The one supplying salted and dried Nile perch for the DRC was characterised by smallholder processors and traders (mainly women; Medard et al., 2019). Tanzanian processors cleaned, descaled, salted and dried the Nile perch, preserving it for up to a year (Medard et al., 2019). Over time, DRC traders began to exploit processors forming hierarchical, ‘mono-centred’ value-chain (Medard et al., 2019). Powerful female middlemen emerged to control trade with the Democratic Republic of Congo, marginalising the women traders that remained (Medard et al., 2019).

The second stream supplied European and Middle Eastern markets, a significant portion going to Israeli armed forces (Abila & Jansen, 1997; Gibbon, 1997a; Lombardi & Anderson, 1998; van der Knapp & Ligtvoet, 2010; van der Knapp, 2013). This chain was dominated by a few actors with large-scale, vertically-integrated businesses with processing factories (Gibbon, 1997a; van der Knapp & Ligtvoet, 2010). Processing plants originally located in the major cities, moved to the lakeshore, where air and road transport infrastructure was developing (Abila & Jansen, 1997). Processing plants in Kenya (and eventually Tanzania and Uganda) developed collection and transport systems, using agents to source fish, purchased by the piece rather than by kilo (Gibbon, 1997a; Beuving, 2010). While this system was decentralised, processing plants usually hired one chief agent to manage logistics and collection operations (Gibbon, 1997a). Field agents were provided with collection boats and cold-storage infrastructure and many field agents had sub-agents (Gibbon, 1997a). Field agents gradually replaced and had a higher socio-economic status than female fish traders (Johnson, 2010). A small number of independent aggregators also operated (Gibbon, 1997a).

Driven by export markets and an increasing local population, Nile perch had become an economically important species (Achieng, 1990; Ogutu-Ohwayo, 1990; Worthington & Lowe-McConnell, 1994; Gibbon, 1997a). The Nile perch value-chain that developed economically benefited fishers and littoral communities through increased spending (Achieng, 1990; Riedmiller, 1994; Jansen et al., 2000; Downing et al., 2014). An estimated 180,000 fisheries-related jobs were created in the 1980s

(Abila & Jansen, 1997). Many fishers reinvested their profits in additional canoes and fishing equipment, while others diversified their investments in livestock, additional wives and households, shops, etc (Jansen et al., 2000; Downing et al., 2014). The introduction had successfully reversed the downwards fisheries production trend with significant economic gains (Gibbon, 1997a). Processing plants often ‘sponsored’ fishers, providing in-kind loans (e.g., nets or engine) to be repaid with fish (Abila & Jansen, 1997; Gibbon, 1997a).

The boom attracted new investors to the fishing industry – i.e., non-fishers who purchased boats and hired crew as a business opportunity (Gibbon, 1997a; Jansen et al., 2000). While fishing activities were traditionally family-operated and fishing crews largely uneducated and literate, the profitability of the Nile perch fishery attracted businessmen and professionals who invested in boats and hired crew (Riedmiller, 1994). Profitability required capital for industrialised and specialised equipment (e.g., larger nets, motors), inaccessible by smallholder fishers (Witte et al., 1999; Pringle, 2005b). Thus, a significant number of boats were no longer owner-operated and absentee ownership increased over time (Jansen et al., 2000). Value-chain activities that were previously filled by family members were replaced by the processing companies’ agents and/or independent traders (Witte et al., 1999; Johnson, 2010). As of the late 1990s, only 6-14% of fishers owned gear or boats; rather, they were mainly employed (Wilson et al., 1999). Boat owners were exclusively male (Geheb & Binns, 1997) and retained 80% of daily catch sales (Riedmiller, 1994). The crew – also exclusively males between 15 and 25 years old – received 20% of daily catch sales and an occasional fish for home consumption (Riedmiller, 1994). Fishers benefited from the export trade: their income increased by 23% per year between 2000 and 2003, despite increasing catch rates and fishing pressure (Ikwaput-Nyeko, 2004). A small number of women were engaged in beach seining (defined as fishing from the beach by wading through shallow waters using a “seine” net), although they were considered ‘helpers’ rather than ‘fishers’ and received a smaller portion of the related income (Fiorella et al., 2015). Women were restricted from the boats due to the physical requirements of hauling nets and cultural expectations that boats and fishing were passed patrilineally (Mwakubo et al., 2007). Littoral household income for food security was highly dependent on catch, although many continued to farm cash crops (Wilson et al., 1999).

In addition to local engagement in fishing, thousands of young men migrated to the lakeshore for fishing employment (Gibbon, 1997a). In Uganda, this migration and increased fishing pressure was correlated with displacement from national conflict (Glaser et al., 2019). Low education and equipment requirements coupled with few employment opportunities made fishing attractive to lower income demographics (Mwakubo et al., 2007; Mkuna & Baiyegunhi, 2019a). In Kenya alone, the number of fishers increased from 11,000 in 1971 to 30,000 in 1995 (Abila & Jansen, 1997). A large portion of fishers also migrated around the lake, following fish (Nunan, 2010; Nunan et al., 2012). Vessel owners set up temporary camps for their migrating crew (Gibbon, 1997a). These camps attracted other fishers looking for work, specialised processors, tradesmen (e.g., net menders),

women to cook and sell food, and the crew's families (Gibbon, 1997a). Because fishermen believed that polygamy was a source of wealth – i.e., that larger families were wealthier (Mwakubo et al., 2007) – migrating men often re-married locally, and some neglected to send remittances to previous wives (Pringle, 2005b; Nunan, 2010). The combination of polygamy and sex work at these camps facilitated the HIV epidemic (Pringle, 2005b; Nunan, 2010; Asiki et al., 2011). These camps grew over time in all three countries, resulting in an increase in number of fishers and their dependents from 480,000 to 1.3 million between 1990 and 2000 (Witte et al., 1999). Because these camps were temporary settlements, they lacked medical facilities further affecting community health (van der Knapp & Ligtoet, 2010). Additionally, they lacked appropriate schools and uneducated youths entered the fishing value-chain due to a lack of employment opportunities (van der Knapp & Ligtoet, 2010; van der Knapp, 2013) – although it seems likely that this may have also been true for educated youths considering a lack of other employment opportunities generally. Eventually, camps became surrounded by other businesses like kiosks, tailors, bars, and nightclubs benefiting from economic spill over (Gibbon, 1997a; Witte et al., 1999; Beuving, 2010). General resource scarcity and competition between actors within nodes created significant social conflict (Nunan, 2010; Glaser et al., 2019). Located in rural areas and islands, these camps were often governed and policed by the vessel owners themselves (Gibbon, 1997a). Fish that was too poor-quality or uncollected by processing factories was preserved (smoked/salted) for local consumption within the camps (Gibbon, 1997a).

Industrialisation of the Nile perch fishery led to marginalised smallholder actors and reduced availability of fish for local consumption (Jansen et al., 2000). The rapid intensification of the Nile perch industry converted the value-chain from artisanal fishing supplying local protein supply to export-oriented industrial fishing (Beuving, 2010)². Fish accessibility decreased for littoral communities due to its increasing price (Witte et al., 1999). Most fishers immediately took Nile perch to landing sites with receiving infrastructure (Beuving, 2010) and sold to cooperatives or to traders, who would transport fish to processing plants or urban centres (Riedmiller, 1994). Trading was highly competitive – the ratio of traders to fishers was three to one (Geheb & Binns, 1997). Fish quality was mainly determined by the colour of the gills (red gills indicated freshness) and differentiated by price (Riedmiller, 1994). As processing plants required fish larger than 1 kg, local consumers were mainly restricted to smaller or poor-quality fish and fish by-products (Abila & Jansen, 1997; Jansen et al., 2000).

Additionally, consequences for local livelihoods were gendered. Self-employed women originally dominated the local processing and trade node (Geheb & Binns, 1997; Pringle, 2005) and were particularly vulnerable to competition from large processing plants (Wilson et al., 1999). The fish

² Due to a lack of export market, the Nile tilapia fishery was not as heavily exploited as the Nile perch fishery (Goudswaard et al., 2002a). Instead, Nile (and the occasional native) tilapia continued to be destined for local or regional markets (Geheb & Binns, 1997). But by the early 2000s, signs of Nile tilapia overfishing emerged – namely, decreasing catch sizes and catch per unit effort (Njiru et al., 2007).

drying business was an alternative to farming for women without land and increased female autonomy (Wilson et al., 1999). While processing plants created jobs, mainly hiring young women, they supplanted more numerous income-generating activities opportunities for local smallholder processors and traders, who were mainly women (Jansen et al., 2000; Johnson, 2010; Olale & Henson, 2013). The commercial sector overtook the processing sector, and many women lost this income-generating activity (Pringle, 2005b). While many women were employed by processing plants, many more lost their livelihoods due to the processing factories (Abila & Jansen, 1997; van der Knapp & Ligtvoet, 2010). Instead, they shifted to valorising carcasses for local and regional consumption (van der Knapp & Ligtvoet, 2010).

With a demand for more affordable Nile perch products, smallholder traders transitioned from fish processing to Nile perch by-product valorisation. Fish carcasses and waste from processing plants were transported by youths on carts to nearby dump sites, where local traders gathered to process carcasses for local consumption (Gibbon, 1997a; Njira et al., 2005). In the late 1980s, livestock feed mills began to use carcasses, eventually using approximately 60% of carcass by-product biomass (Abila & Jansen, 1997; Jansen et al., 2000). At first, fish carcasses were given away freely, but eventually became sold once these valorisation streams developed (Gibbon, 1997a). Carcasses became so expensive that many locals could no longer afford to eat them (Abila & Jansen, 1997). Bladders were particularly valuable dried for Asian markets (Gibbon, 1997a). Surplus catch, heads and carcasses were smoked and fried for local consumption, using cotton plantation waste for fuel (Riedmiller, 1994; Gibbon, 1997a). Dry-salted fish was the preferred preservation method because it could be done year-round and preserved the quality better than smoking (Gibbon, 1997a). Additionally, firewood prices were higher than salt prices (Gibbon, 1997a). Wood consumption from smoking was significant: an estimated 45 tonnes of wood was used monthly per beach for smoking fish and the need for wood for smoking contributed to deforestation and further lake degradation (Riedmiller, 1994). Despite regulations aimed at preserving forests and preventing overfishing and destructive fishing practices, local governments lacked resources for enforcement (Riedmiller, 1994; Etiegni et al., 2011).

3.2.4 Nile perch ‘Boom and Bust’ era (1990- 2016)

The industrialisation of the Nile perch fishery, including Nile perch processing plant development and resulting fishing pressure, led to the first ‘bust’ period, where Nile perch catch halved between 1990 and 1991 (Riedmiller, 1994). Fishers blamed beach seine net fishing, which often harvested from near-shore breeding grounds (Riedmiller, 1994; Gibbon, 1997a). In response to the crash, each country created regulations to sustainably manage the fishery– for example, gear restrictions and a ban on trawling and drift nets, (Schindler et al., 1998; Wilson et al., 1999; Jansen et al., 2000; van der Knapp, 2013). However, regulations were uncoordinated between the three countries, went largely unenforced, and boats labelled for transport continued trawling and drift netting, resulting in

continued overfishing (Jansen et al., 2000). Many restrictions were criticised because they favoured large-scale fishing operations and marginalised smallholder fishers (Wilson et al., 1999; Jansen et al., 2000). For instance, regulations that required that all Nile perch be processed through factories for export quality assurance marginalised smallholders because processing companies were vertically integrated (Njiru et al., 2008a). As another example, banning beach seines supported fishery populations and was relatively easier to enforce, but it reduced fishing access to people who could not afford a boat (Wilson et al., 1999). Large, vertically-integrated value-chains controlled by wealthy processing plant owners marginalised fishers, particularly smallholders unable to compete nor be integrated into the processing plant fishing networks (Jansen et al., 2000).

Large international investments into processing plants had created a large demand for Nile perch, driving more fishers to the lake (Jansen et al., 2000). Many of the Nile perch processing factories invested in their own fishing fleets with trawlers, marginalising efforts of smallholder fishers (Jansen et al., 2000). While Nile perch populations were stable over longer time periods, Nile perch average body size decreased (Njiru et al., 2008c, although this is also contested by Kolding & van Zweiter, 2024). Processing plants began accepting smaller Nile perch and improving processing efficiency, further reducing Nile perch availability for local consumption (Abili & Jansen, 1997; Jansen et al., 2000). Fishers began targeting juvenile Nile perch to supply the demand (Jansen et al., 2000). Other fishers – particularly those whose households depended on income from Nile perch – took greater risks, like venturing into deeper waters despite extreme thunderstorms characteristic to the region creating drowning risk (Eggert & Lokina, 2007; Beuving, 2015; Thiery et al., 2016; Thiery et al., 2017; Peter & van Zwieten, 2018; Waniha et al., 2019; Whitworth et al., 2019; Woodhams et al., 2019). Drowning became a greater mortality risk than other diseases in the area (Whitworth et al., 2019). Conflict between fishers escalated, culminating in illegally armed gangs and piracy on the lake (Jansen et al., 2000). Many fishers increased their farming efforts and re-diversified their livelihoods in light of the decline; however, a lack of agricultural investment and nutrient-poor soils prevented farmers from realising the same profits as from the Nile perch fishery (Pringle, 2005b; Beuving, 2015).

Due to the economic importance of the Nile perch fishery, international regulatory interventions to sustainably manage Nile perch stocks and optimised the value-chain were suggested (e.g., Abila & Jansen, 1997; Cheke & Ward, 1998; Ogutu-Ohwayo, 2004; Matsuishi et al., 2006). Thus, the Lake Victoria Fisheries Organisation (LVFO) was a multi-national governing body formed in 1994 to cooperatively regulate and standardize legislation concerning Lake Victoria's fisheries (Ntiba et al., 2001). Managing the lake had three competing priorities: increasing the biodiversity of the lake's ecosystem, economic exploitation of the fishery, and supporting food security (Wilson et al., 1999; Jansen et al., 2000). For example, the LVFO agreed upon a minimum catch size to encourage the harvest of mature Nile perch, relieving pressure on haplochromids and increasing pressure on booming populations of ochonga (*C. nilotica*; Njiru et al., 2005). Managing socio-economic and

environmental requirements was tricky: closed seasons were not implemented due to the hardships it would impose on fishers (Balirwa, 2007). Much later in 2016, the scope of the LVFO expanded and Burundi became the fourth member in 2018 (FAO, 2024). Despite the LVFO, inconsistencies between each nation's regulations persisted and policies remained under-enforced due to underfunding (Geheb & Crean, 2003; Njiru et al., 2005). Due to high migration around the lake, fishers were often unaware of regulations in the country they moved to (Nunan, 2010). Even when they were aware of regulations, fishers were more likely to conduct illegal fishing activities when they felt the risks of getting caught were lower (Eggert & Lokina, 2010; Cepić & Nunan, 2017). Furthermore, because fishers largely understood to be open access – after a small nominal fee for a fishing license (Njiru et al., 2018) – and publicly owned, fisher communities' self-governance failed to restrict the number of fishers on the lake (Geheb & Crean, 2003).

Indeed, overfishing was and continues to be blamed for Nile perch population decline in Lake Victoria, throughout academic, government, and the public news' rhetoric; however, Kolding and van Zweiten (2024) claim that Nile perch biomass has actually been stable since 1993. The crash in 1991 created a panic, but total catch data suggests that Nile perch biomass were thereafter stable. They explain that catch has been confused with catch-per-unit-effort: due to the expansion of fisher populations, catch-per-unit effort has decreased, creating the misleading perception that populations are declining. Eutrophication, rather than fishing pressure, may have been a greater threat to Nile perch populations (Kolding et al., 2008; Hecky et al., 2010).

Despite stable Nile perch populations, the Nile perch industry experienced a second economic bust in 1997. Nile perch trade plummeted in 1997 due to EU import bans arising from quality and food safety concerns (Njiru et al., 2008a). The ban had severe economic and social affects in all three countries' fishing communities (Josupeit, 2006). After EU bans resulting from food safety concerns, it was illegal to sell the fish from the boat, further reducing local access (Beuving, 2010; Nunan, 2010). Women-owned periphery income-generating activities were negatively affected by trade bans due to less circulating cash, which further exacerbated local food insecurity (Geheb et al., 2008).

Subsequent years were smattered with 'boom and bust' cycles (Figure 6; Ogutu-Ohwayo, 1990; Mkumbo et al., 2007). Authors once again argued that Nile perch populations showed signs of decline, attributed to the top-down effect of fishing pressure (Geheb & Binns, 1997; Jansen et al., 2000); however, in light of Kolding and van Zweiten's (2024) arguments, it is likely that the 'boom and bust' cycles were economically driven rather than a result of Nile perch population decline. Indeed, smoking kilns supplying regional markets also closed: over 100 local smoking kilns in Kenya were abandoned between 1995 and 2000, leaving only one in operation in 2000 (Jansen et al., 2000).

Enforcement of regulations struggled, but processing plants declined anyways. Illegal fishing practices continued into the early 2000s (Njiru et al., 2007; Lawrence, 2013; Cepić & Nunan, 2017), and by 2007, processing plants were operating at 50% capacity due to low supply (Johnson, 2010).

Although enforcements against trawling finally solidified by 2010 (van der Knapp, 2013), preferential use of long lines had increased by 2008, mainly because they were locally manufactured whereas nets were imported (Beuving, 2015). Key informants report that trawlers were too expensive to operate (e.g., fuel costs), and fisher labour in artisanal boats were cheaper and more reliable to run. Whether due to unprofitability, poor supply, or both, these Nile perch businesses slowly folded. By 2016, Nile perch exports from all three countries combined was less than 1500 tonnes (Figure 8). Today, key informants from my interviews report that only one processing plant operates in Kenya.

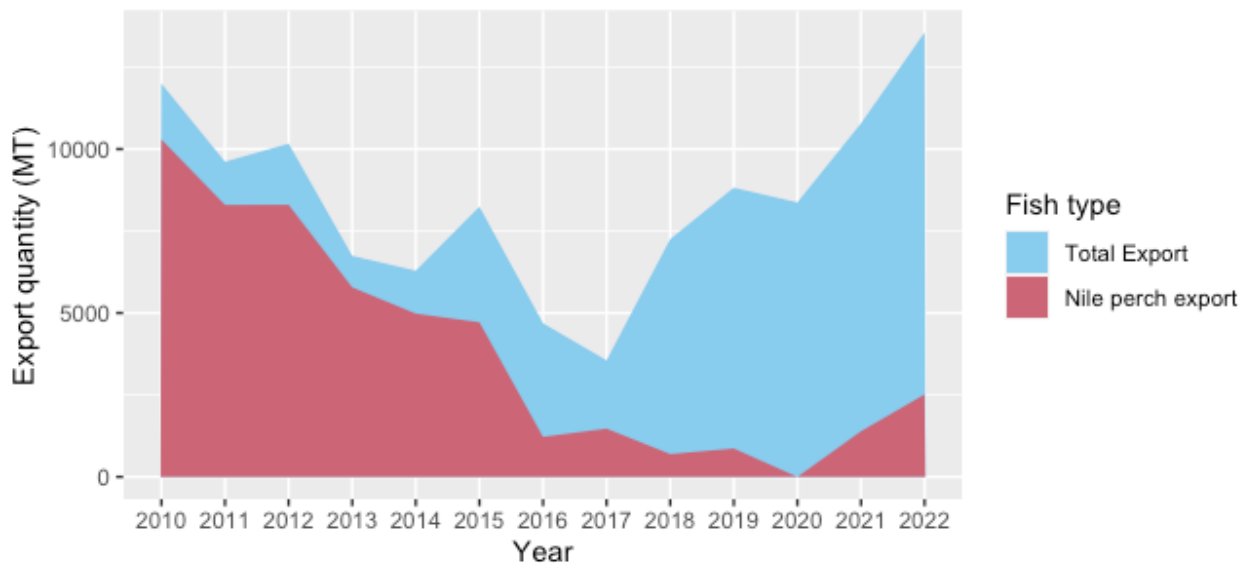


Figure 8: Total quantity of fish and seafood product exports from Kenya, showing the portion of which was Nile perch exports for the years 2010 through 2022 using data from KeFS (2022).

Fishing pressure continually mounted over time. During ‘boom’ periods, people were allured by fisheries’ perceived profitability and many became fishers due to low barriers to entry; droves of new fishers increased fishing pressure, driving down catch-per-unit effort (Geheb & Binns, 1997; Pringle, 2005b). Fishers understood that the number of fishers drove down their catch; however, they also believed access should be unrestricted because fishing was a financial ‘safety net’ for littoral households faced with poverty and food insecurities (Geheb & Crean, 2003). Moreover, fishers perceived fishing as a short-term means of procuring cash; thus, they were uninterested in the fishery’s long-term health, which prevented them from supporting a closed exclusive fisheries system (Barratt & Allison, 2014). As the resulting profits were distributed among more fishers, ‘boom’ periods did not necessarily lead to improved income for fishers (Geheb & Binns, 1997). Fisher populations continuously grew, as fishers did not exit during ‘bust’ periods because alternative income-generating activities were limited (Geheb & Binns, 1997; van der Knapp & Ligetvoet, 2010; Mkuna et al., 2020). Additionally, fishers often formed friendship peer groups, where members were often part of the same crew and supported each other in securing work, accessing loans, providing business advice, among others (Beuving, 2010; Beuving, 2015; Nunan et al., 2018; Allegretti, 2019).

Close kinships coupled with familial independence and abundant leisure activities contributed to fishers' strong preference for their lifestyles within the fisheries industry (Beuving, 2010; Sileo et al., 2016). Fisher identities and the strength of their attachment to fishing is also apparent in Scotland (Ross, 2015). Instead of exiting as the Nile perch fishery declined, fishers stayed (Beuving, 2010). Over time, fishing efforts increased and fishing pressure was sustained, often accompanied by new and more efficient fishing technologies (Geheb & Binns, 1997; Jansen et al., 2000; Njiru et al., 2007; van der Knapp & Ligetvoet, 2010).

The Nile perch boom did not result in long-term economic benefits to the fishing community. Although fishers perceived fishing as a 'means to an end' (Barrate & Allison, 2014), many fishers quickly spent money rather than saving or investing it (van der Knapp, 2013). Fishers did not save because they felt income from fishing was readily available and few banking facilities existed (Geheb & Binns, 1997; van der Knapp & Ligetvoet, 2010). This led to their frustration, as fishing became a long-term profession rather than the short-term temporary occupation, or an 'ends to a means' that they had expected (Barratt & Allison, 2014; Allegratti, 2019). Arguably, those in the Nile perch value-chain were less reliant on savings: they reaped the economic benefits from the export trade and livelihood diversification actually reduced their overall income (Olale & Henson, 2013). In contrast, Nile tilapia and omena fishers who had access to savings were also more able to diversify their livelihoods (e.g., via farming) and thus increase their income (Olale & Henson, 2013). For these fishers, a higher reliance on fishing was linked to lower total income, and development projects to support income diversification from fishing was recommended as a poverty-alleviation strategy (Olale & Henson, 2013; Mkuna et al., 2020).

3.2.5 Human welfare and the Nile perch industry

Disease was a dominant topic in the literature, accounting for 61% of articles on livelihoods and 17% of articles on all topics. Littoral communities were susceptible to schistosomiasis and other water-borne parasites (Ogola et al., 2014; Webb et al., 2016; Munisi et al., 2017). The prevalence of mosquito-borne diseases (e.g., malaria, yellow fever) were worsened by fishing activities that created standing water and breeding grounds for the mosquitos (Mukabana et al., 2019). Unlike in other areas where illness decreased fishing effort, illness around Lake Victoria did not affect fishing effort; rather, ill fishers were more likely to use illegal fishing methods to increase their catch per unit effort (Fiorella et al., 2017).

As a result of increased cash flow from international investments and an influx of migratory young men between the late 1970s and late 1990s, alcoholism and sex work increased (Jansen et al., 2000). This combination began to threaten public health through risky behaviours (e.g., unprotected sex; Tumwesigye et al., 2012; Kiwanuka et al., 2014; Mazigo et al., 2015; Sileo et al., 2016; Kiwanuka et al., 2017; Sileo et al., 2019a; Kiene et al., 2019a). HIV/AIDS and other sexually transmitted disease rates around the lake soared beginning in the 1980s (e.g., Gibbon, 1997a; Mwakubo et al., 2007;

Asiki et al., 2011; Kwena et al., 2012; Seeley et al., 2012; Tumwesigye et al., 2012; McArthur et al., 2013; Kiwanuka et al., 2013; Kwena et al., 2013; Kiwanuka et al., 2014; Mazigo et al., 2015; Kapesa et al., 2018; Kwena et al., 2019). While HIV rates stabilised in the late 1990s, people in the fish value-chain remained a high-risk group (Yebra et al., 2015; Kapesa et al., 2018; Bbosa et al., 2019; Kwena et al., 2019). Extra-marital affairs (in part due to domestic violence and sexual dissatisfaction) and mobility were significantly associated with the risk of contracting HIV (Kwena et al., 2013; Kwena et al., 2014; Kwena et al., 2017; Kwena et al., 2019). Some surveys estimated HIV rates of 20 to 46% among fishers and fish traders, identified as particularly high-risk groups (Tanzarn et al., 2005; Kiwanuka et al., 2013; Kiwanuka et al., 2014; Kwena et al., 2019). Herpes simplex virus and human papillomavirus infection was present in 64% and 58% of Kenyan fishers (Ng'ayo et al., 2007; Ng'ayo et al., 2008). Infected individuals failed to communicate with their sexual partners, further facilitating the spread (McArthur et al., 2013). Risk factors for alcoholism and risky sexual behaviour were researched (e.g., alcoholism was correlated negatively with religiosity; Tumwesigye et al., 2013; Kiwanuka et al., 2017) and interventions to prevent transmissions were attempted (Balyagati et al., 1995; Abaasa et al., 2015; Nanvubya et al., 2015; Ssetaala et al., 2015; Bogart et al., 2016; Bogart et al., 2017; Sileo et al., 2019a; Sileo et al., 2019b; Kiene et al., 2019a; Sellers, 2019; Tumwine et al., 2019).

Women also migrated to and around the Lake Victoria region, further contributing to the spread of HIV and sexually transmitted disease within the fishing industry (Camlin et al., 2013; Kwena et al., 2013; Bbosa et al., 2019; Kwena et al., 2019). A few women became international traders, mainly transporting fish to the DRC (Medard, 2019). These women entered the fish trade to augment their household income for food security, education fees, and to gain economic independence (Medard, 2019). Other, women moved to littoral landing sites as a temporary livelihood strategy for escaping inland poverty and vulnerabilities, usually invited by a friend or family member already working there (Pearson et al., 2013; Camlin et al., 2013). Migrants usually migrated alone, either unmarried or leaving their family behind (Nunan, 2010; Camlin et al., 2013). Their contacts sometimes provided them with a job, or they set up auxiliary service businesses like kiosk businesses (Pearson et al., 2013). Key informants and the literature implied that both men and women intended to migrate for fish work temporarily, but ultimately stayed, unable to save up enough cash to return home (Beuving, 2010; Camlin et al., 2013; Pearson et al., 2013). Indeed, social networks were critical to women processors (Medard et al., 2019). Generally, women processors were highly dependent on financial and advisory support from other processors, moreso than boat owners or boat crew (Nunan et al., 2018). Women processors' social networks extended across several beaches, reflecting their habit of working across two or three sites; male boat crew's social networks were limited to single beach locations, a result of boat crews migrating together around the lake (Nunan et al., 2018; Allegretti, 2019). Maintaining ongoing business and/or sexual relationships with fishers was paradoxically a motivation for female traders to not move around the lake (Nunan, 2010). Some estimates suggest up to 40% of fishers moved around the lake, compared to only 9% of female traders

(Nunan, 2010). Women were more likely to have savings, likely because they were more stationary than men moving between landing sites (Nunan, 2010). Although unsupported by literature, it may have been that women were also more likely to save because they were more responsible for taking care of the homestead and less likely to spend money on alcohol and the beach social life. This was possibly due to child-care responsibilities: children were either sent to boarding schools or left at a landing beach to where mothers would need to return (Nunan, 2010).

Many women processors and male crew members engaged in ‘Sex for fish’ transactions, where women exchanged sex for access to fish. Transactional sex was a key strategy for women to avail fish and access natural resources, considering their restriction to lower-value value-chain nodes (Fiorella et al., 2015). Sex-for-fish resulted from high competition within a highly gendered value-chain (i.e., that women and men are positioned in the value-chain *because* of their gender; Medard et al., 2019) and contributed to the HIV epidemic (Geheb & Binns, 1997; Mojola 2011; Fiorella et al., 2015; Naigino et al., 2019). In 2012, approximately a third of male fishers participated in transactional sex, including for fish, food, or accommodation (Fiorella et al., 2015). Women in approximately 10% of households participated in transactional sex and were more likely to do so if they were vulnerable – i.e., had a lower education status, were food insecure, and were unmarried, despite fearing HIV infection (Fiorella et al., 2015). In comparison, female entrepreneurs (both migrants and locals) with savings or access to credit were more likely to build successful auxiliary businesses and avoid fish processing and sex-for-fish relationships (Pearson et al., 2013). Several female entrepreneurs were able to become wealthy business owners, although the majority remain subjugated (Pearson et al., 2013). A later development pilot project that built three boats for women to own and manage, significantly improved the female boat-owners welfare and positively altered the perception of women in the community (Nathenson et al., 2017). It also reduced depression, mental health issues, transactional sex, domestic violence, and HIV transmission (Nathenson et al., 2017).

Malnutrition and poverty in fishing communities were also ubiquitous in the literature. While the first mention of malnutrition was in Abila and Jansen (1997), the topic became more prevalent beginning in 2008. Poverty around Lake Victoria has been described as a ‘wicked’ problem, i.e., a problem that is difficult to solve due to its complexity (Onyango & Jentoft, 2010). The littoral population around Lake Victoria has historically been considered food insecure (Njiru et al., 2008a). In littoral Kenyan communities in the late 1990s, an estimated 50% of the population failed to consume enough calories (Abila & Jansen, 1997). More recent research showed that malnutrition was rampant: in the early 2000s, approximately 40% of children were stunted and energy consumption was below the 2600 calories per day recommended by the FAO (Geheb et al., 2008). Yet, malnutrition was lower in littoral communities compared to agricultural hinterlands and national average, hypothesized due to the Nile perch trade (Geheb et al., 2008). Some authors argue that the Nile perch industry improved welfare around the lake due to spill over effects from the economic

activity (Eggert et al., 2015). Certain social welfare indicators increased between 1993 and 2008, measured by increased education levels, increased average income, lower household expenditure on food, and less of the population below the poverty line; however, these changes were more pronounced in urban compared to rural areas (Eggert et al., 2015).

But despite the economic boom, financial benefits were inequitably distributed, and income was concentrated among mainly boat and factory owners (Witte et al., 1999). The economic boon was limited to a few boat owners who managed to expand their businesses rapidly; however, most fishers did not have sufficient cash to expand their business and thus remained impoverished (Beuving, 2010). Thus, other authors argued that the poverty-stricken and food insecure region failed to reap infrastructural or human developmental benefits from the Nile perch industry (Abila & Jansen, 1997). The Nile perch industry's economic success did not translate into improved food security around the lake (Geheb et al., 2008; van der Knapp, 2013).

While fishing remained part of local identities³ (a strong affiliation with fishing identifies among fishing communities is apparent globally; O'Driscoll-Adam, 2014), particularly for the Luo ethnicity, the Nile perch industry reframed the fish as a regional commodity for exploitation and financial gain (Allegretti, 2019). This shift was triggered by the economic boom connected to the export market (Allegretti, 2019). Instead of a family operated activity, fishing became an occupation and fishing identities became "grounded in individual, rather than collective experience" (Allegretti, 2019). Resilient fishing identities in Scotland were similarly characterised by community with other fishers, a shared value of freedom and autonomy, and exclusion of nonfishers (Ross, 2015). In Tanzania, the Nile perch trade has "weakened people's sense of identity rooted in symbolic meanings and practices of fish consumption within the domestic realm" (Allegretti, 2019). Only one article on fishing identities was identified and this warrants more research in this study area to adequately inform fisheries policy (Ross, 2015; Delgado-Ramírez et al., 2023).

Fish consumption had historically been a central component of the main meal, but commoditisation during the Nile perch explosion reduced local accessibility and changed consumption patterns from larger fish to omena (Allegretti, 2019). By 1997, Kenyan households reported eating significantly less Nile Perch due to increased prices, relative decrease in household income, and local unavailability of Nile perch (Abila & Jansen, 1997). This inaccessibility of fish was more pronounced for poorer demographics (Abila & Jansen, 1997). Household consumption shifted away from larger fish to omena, commonly less preferred than 'real' fish (Eggert et al., 2015; Allegretti, 2019). Omena was not considered 'real fish' and was not considered good enough to serve visitors (Allegretti, 2019). While the Nile perch trade did not affect the availability of omena for local consumption (van

³ 'Social Identities Theory' explains how our perception of self 'identity' both shapes and is shaped by our views of our social group's members and common habits (originally introduced by Tajfel and Turner 1979, as cited in Hogg 2016).

der Knapp, 2013), food security worsened because of inequitable distribution of economic profits (Geheb et al., 2008; van der Knapp, 2013).

The failure of the Nile perch industry to translate into improved food security was attributed to the fact that men controlled the profitable nodes of the value-chain: unlike women, who direct more of their income towards food and household expenditures, men preferred to reinvest earnings in their business or spend it on alcohol or sex workers (Geheb et al., 2008; van der Knapp & Ligtoet, 2010; van der Knapp, 2013). Women were pushed out of higher-value nodes (e.g., Nile perch trading) to periphery activities (e.g., carcass processing):

The kinds of income-generating niches that women are allowed to exploit are limited and their access to resources often curbed by competition with men, the strictures of traditional gender roles and the limited assets available to women to establish businesses. (Geheb et al., 2008:90)

Fishing communities' leisure industry created livelihood opportunities for women outside the fishery value-chain; indeed, profitable income-generating activities for women were not directly related to fishing because women were being pushed out of the fish value-chain (Pearson et al., 2013). In the Nile perch industry, this meant that processing and trade jobs usually occupied by women smallholders (as seen in the tilapia trade) were replaced with fewer processing jobs at large factories and male traders. While still technically within it due to jobs at processing factories, these jobs were low-paid and limited in number. Glaser et al., (2019:7) remarked "In both conflict and fisheries, women were disproportionately relegated to subordinate, less remunerative, and/or socially less-recognized positions." Gendered inequalities of power within the value-chains risks the food security vulnerable groups (Glaser et al., 2019). The aforementioned small targeted project that established women boat owners effectively brought women back into higher-value nodes with successful outcomes: women boat-owners used their income for school fees and household expenditures (Nathenson et al., 2017).

Indeed, much of the literature paints Lake Victoria's littoral communities as in constant health crisis, social strife, and food insecurity (Johnson, 2017). However, ethnographer and food security researcher Johnson (2017) refutes this portrayal: she reflects on a rich and biodiverse small-scale, localised fishery value-chain, dominated by women and overlooked, that is the keystone for local food security. She found that, while not as economically impressive as the Nile perch industry, tilapia and small fish value-chains still engage women and contribute to food security and local food culture. She argues that academia and policy-makers have failed to recognise the vibrant and immense nutritional and cultural value of these other fisheries. Her ethnographic work urges for researchers to look beyond economics and the Nile perch value-chain to Lake Victoria's other fisheries understand their full contribution to littoral community wellbeing.

3.2.6 Community-based governance strategies

A portion of the literature concentrated on the community-based fisheries governance strategy employed around Lake Victoria. The governing bodies of all three countries (Tanzania, Kenya, and Uganda) implemented community-based fisheries management, a decentralisation of natural resource governance to littoral communities (Wilson et al., 1999). Co-management, theoretically for improved regulatory enforcement, was widely encouraged by academics (Jansen et al., 2000; Crean & Geheb, 2001; Njiru et al., 2005; Mkumbo et al., 2007; Njiru et al., 2007; Balirwa, 2007). Researchers stressed the importance of capitalising on indigenous knowledge of the fisheries and their conservation (Pringle, 2005b). Additionally, development organisations pressured governments to devolve power after top-down approaches had failed to deliver sustainably managed fisheries (Etiegni et al., 2019). Community-based fisheries management and co-management models attempted to return governing power to littoral communities who, prior to the Nile perch fishery industrialisation, has largely governed themselves through traditional governance systems (Geheb, 1997; Jansen et al., 2000). In these traditional governance systems, elected representatives formed ‘beach committees’ and ‘fishermen co-operatives – beach committees regulated and solved conflict between fishers while co-operatives facilitated sales between fishers and agents (Jansen et al., 2000). With the Nile perch industry boom, national-level governments had become increasingly involved in these beach committees and co-operatives to emphasise foreign exchange earnings and fishers lost their sense of agency (Jansen et al., 2000). In the return to community-based management, Jansen et al., (2000) urged for the inclusion of a large variety of stakeholders from both the Nile perch and omena value-chains: because the omena and artisanal value-chain was largely ignored by governments due to its lower economic value relative to Nile perch, Jansen et al., (2000) highlighted the risk that small-scale fishers and women omena processors were becoming marginalised.

Community-based fisheries management was implemented between 1990 (Tanzania) and 2007 (Kenya), in the form of Beach Management Units (BMUs; Njiru et al., 2007; Etiegni et al., 2020). Each country implemented congruent BMU legislation, detailed in depth by Lawrence (2013). Every boat was required to register with a BMU, and by 2006, 1069 BMUs existed around the lake (Nunan et al., 2012). BMUs were required to democratically elect members representative from all major actor groups: BMUs must include 30% boat owners, 30% boat crew, 30% ‘others’ (e.g., fish processors, net repair), and 10% fishmongers (Nunan et al., 2012). Additionally, three of the nine-twelve members had to be women (Nunan et al., 2012; Etiegni et al., 2019). In all three nations around Lake Victoria, beach-level authority, democratic election processes, and multistakeholder representation was encouraged (Geheb et al., 2007).

Yet, BMU operations lacked legislation, regulatory authority, financial support, and had an ambiguous role, and thus were mainly communication bodies between fishers and the Fisheries Departments (Njiru et al., 2007; Geheb et al., 2007; Lawrence & Watkins, 2012; Lawrence, 2013;

Njiru et al., 2014; Obiero et al., 2015; Etiengi et al., 2019). This communication was mainly one-way, from the government to the fishers and failed to facilitate fisher co-participation in management (Etiengi et al., 2020). BMUs were expected to finance their own operations: in Kenya, fishers' funded the BMUs through their registration fees (Etiengi et al., 2020). Indeed, fisher knowledge of regulations improved (Etiengi et al., 2017; Mkuna & Baiyegunhi, 2019b). Many BMUs felt their role was to ensure peace, order, and cleanliness, as beach leaders once did (Geheb et al., 2007). In Uganda, BMUs had more power and were assigned to police fishers and ensure fisheries regulations were adhered to (Geheb et al., 2007; Lawrence, 2013). BMUs in Uganda began forming cooperatives around 2010 to assist with marketing campaigns (van der Knapp, 2013). Around the same time, Tanzania attempted to provide the BMUs with greater clarity: policy documents detailed that BMUs were expected to enforce fisheries laws and raise funds for their operations (Medard et al., 2016).

BMUs faced several challenges regarding successful representative co-management. Guidelines about representation were ineffective in all three countries, because boat owners were disproportionately resourced to support and enable their own election (Nunan et al., 2012). Their ambiguous role resulted in 'institutional bricolage', where BMUs were highly influenced by local social structures (Nunan et al., 2015). Many fishers deferred to elders and chiefs due to historical hierarchies, yet BMUs stripped these leaders of their power over fisheries, relegating them to solve social disputes (Etiengi et al., 2020). For instance, mobile fishers went largely unrepresented due to the legislation's failure to consider migration (Nunan et al., 2012). Because of their migration, many fishers lacked engagement with any particular BMU, and this was a significant barrier to BMUs impact (Nunan, 2010; Nunan et al., 2012). BMUs also failed to equitably represent stakeholders (Etiengi et al., 2019; Etiengi et al., 2020). BMUs often failed to include women representatives at all, let alone meet their gender quota (Nunan et al., 2012). Positions of power within the BMU were dominated by boat owners, who used their wealth to gain powerful positions (Nunan et al., 2012; Etiengi et al., 2019; Etiengi et al., 2020). As crew members moving around the lake, fishers had limited power (Nunan et al., 2012). Further, fishers perceived 'participation' as supporting (or not) government rather than active co-management engagement (Etiengi et al., 2020). Poor BMU financial transparency with their constituency created mistrust and opportunities for corruption (Nunan et al., 2012; Lawrence, 2013; Barratt et al., 2015; Medard et al., 2016; Etiengi et al., 2017; Nunan et al., 2018).

Despite BMUs, illegal fishing activity continued (Munubi & Nyakibinda, 2020), where most fishers (regardless of targeted species) consciously violated regulations for economic gain because their poverty level meant they could not afford moral concerns (Etiengi et al., 2011; Barratt et al., 2015; Cepić & Nunan, 2017; Etiengi et al., 2017; Mkuna & Baiyegunhi, 2020). Fishers were financially motivated to use illegally small mesh nets⁴ because processing plants prioritised fish volumes over size (Etiengi et al., 2011). Aforementioned close kinship ties, lack of engagement with BMUs, and

⁴ Small mesh nets were illegal because they capture immature fish, preventing brooder recruitment.

disagreement about damaging activities meant that fishers were unwilling to report these observed illegal activities (Etiegni et al., 2011; Nunan et al., 2012; Nunan et al., 2015; Luomba et al., 2016; Etiegni et al., 2017). As fishers themselves, BMU members also felt a commitment to their community, and often ignored illegal fishing, knowing their communities' livelihoods depended on catch (Barratt et al., 2015; Cepić & Nunan, 2017). Social ties limited the fisheries' co-management potential (Nunan et al., 2018). Many BMU members who owned boats were reluctant to cease illegal fishing because their own livelihoods were dependent on their catch (Barratt et al., 2015; Cepić & Nunan, 2017; Etiegni et al., 2017; Etiegni et al., 2019). BMUs worsened inequalities by creating an elite group, which reduced potential benefits of co-management (Etiegni et al., 2019). Thus, BMUs have been considered largely ineffective at supporting sustainable and equitable fishing practices (Etiegni et al., 2011; Lawrence & Watkins, 2012; Nunan et al., 2012; Lawrence, 2013; Njiru et al., 2014; Mkumbo & Marshall et al., 2014; Obiero et al., 2015; Luomba et al., 2016; Etiegni et al., 2017; Etiegni et al., 2019; Mkuna & Baiyegunhi, 2019b; Etiegni et al., 2020).

In 2014, academic debates over whether Lake Victoria should be managed from a fisheries or holistic approach emerged. Some authors argued that the lake was clearly overfished due to the sheer quantities of fishers and decreasing recorded catch rates (Njiru et al., 2014; Raymond et al., 2019). These authors believed other problems, like eutrophication, were outside of anthropogenic control and too difficult to manage (Mkumbo & Marshall et al., 2014). Others maintained that eutrophication was a larger issue affecting fisheries than overfishing and urged for an ecosystem-based approach (Downing et al., 2014; Njiru et al., 2018; Badamasi et al., 2019). This approach would require improved watershed management – considering the difficulties with international lake management, internationally integrated watershed management would likely present challenges. Some authors supported increasing fishing effort of lower-trophic fisheries, i.e., omena, for improved local food security (Kolding et al., 2008; Natugonza et al., 2016). Others urged for reducing fishing pressure on haplochromid and tilapia species to sustain populations across the trophic web (Raymond et al., 2019). More recent modelling has suggested continued pressure on Nile perch but eliminating fishing pressure on haplochromids would result in the largest biomasses of Nile perch and omena, compared to reducing fishing pressure on Nile perch (Nyamweya et al., 2017). Rather, continued fishing pressure on Nile perch would result in the most ecosystem benefits (Nyamweya et al., 2017). Thus, improvements in Nile perch fishing efficiency have been suggesting, including improved access to credit and fishing equipment subsidies (Mkuna & Baiyegunhi, 2019a).

Several recommendations for improved governance have been made. For instance, researchers encouraged the development of alternative income-generating activities to reduce the number of fishers on the lake (Njiru et al., 2007). While this is a common recommendation globally (Hillborn, 2007), lessons from elsewhere suggest significant challenges (Hanh & Boonsstra, 2019; Engie, 2015; Diedrich et al., 2019; Avila-Forcada et al., 2020). In Africa, successful transitions may be supported by strategies that combine fishing with alternative livelihood opportunities (Baker et al., 2004;

Brugère et al., 2008). Due to actors' reliance on social networks for financial credit, credit provisioning based on legal compliance could support regulatory adherence (Nunan et al., 2018).

3.2.7 The omena fishery

Omena was a native cyprinid to Lake Victoria, whose population boomed in the absence of their haplochromid predators and lack of Nile perch predation (see: 3.2.2). Omena was primarily caught as by-catch by women wading through shallow waters with baskets or families beach seining (Witte et al., 1999; Jansen et al., 2000). Omena catch significantly increased in the 1960s when fishers started using finer mesh nets to target tilapia (prior to the explosion of the Nile perch fishery; Abila & Jansen, 1997; Witte et al., 1999). As a species historically consumed locally, it was traded and consumed by the growing littoral populations who migrated to the Lake to participate in the Nile perch industry. As of 1970, omena was targeted using kerosene lamps with reflectors (replaced with LED photovoltaic systems in 2014, often purchased by boat owners using microcredit schemes; McHenry et al., 2014) that attracted plankton, which in turn attracted omena (Gibbon, 1997b; Jansen et al., 2000). Thus, this method was most effective during new moon, because the full moon created too much ambient light for the lamps to attract omena (Jansen et al., 2000). Most omena fishers used scoop nets, but wealthier boat owners, often nonlocals who had migrated to the region for the Nile perch business, used seine nets (Gibbon, 1997b). Omena was ubiquitously consumed in littoral communities, even affordable by the poor as thus known as “the poor man’s food” (Abila & Jansen, 1997). Its portionability is particularly important for its accessibility, as poorer people living day-to-day can buy any portion size depending on the money they have for that day; in contrast, most larger fish are sold whole and are not portioned by the trader, becoming inaccessible to people without enough money to buy the whole fish (Abila & Jansen, 1997; Medard et al., 2019).

Omena was fished entirely for local consumption until 1987, when feed mills started accessing poorer-quality omena instead of relying entirely on imported fishmeal (Jansen et al., 2000; Njira et al., 2005). As a result of the new demand, fishing pressure on omena increased (Jansen et al., 2000). Trawling for omena and fulu to supply animal feed processing plants in Kenya, Tanzania, Uganda, and Zaire began (Gibbon, 1997a). Small ring nets (circular nets with sinkers, lifted periodically throughout the night) were introduced in the 1990s and quickly became the dominant method among full-time commercial fishers (Gibbon, 1997b). By the mid 1990s, an estimated 70-75% of omena catch was destined for feed mills – a concern for food security given that over half the Kenyan littoral population was considered malnourished (Abila & Jansen, 1997; Jansen et al., 2000). Jansen et al., (2000) warned that continued pressure and competition could also reduce local access to omena for consumption. Some urged governments to ban exports to livestock processing plants and control fisheries trade to protect peoples' access to affordable fish (Njiru et al., 2008a). It was estimated that ceasing omena supply to fishmeal factories would have raised per capita fish consumption in Kenya by 2.3kg, or 80% (Abila & Jansen, 1997).

The omena value-chain differed from the Nile perch value-chain in several ways. Due to its low-value, omena was ignored by international investors, who focused on Nile perch: as of the late 1990s, no international owners existed in the omena value-chain (Jansen et al., 2000). Most omena boats were almost entirely absentee owned (i.e., owned by men who did not participate in the fishing operations), including a small number of wealthy women-owned boat fleets (Jansen et al., 2000; Pringle, 2005b). Key informants suggest that boat owners were both locals and migrants to the area who had originally targeted Nile perch or tilapia but pivoted into the omena fishery as demand from feed mills and competition in the Nile perch and tilapia fisheries escalated. Fisher recruitment, demographics, and payment methods were similar to that of the Nile perch fishery, but the economic value of omena was significantly lower (Gibbon, 1997b). As in the Nile perch fishery, fishers lived in camps where young women would provide cooking and sex work services (Gibbon, 1997b). As of 1990, Gibbon (1997b) estimated 4000-7000 omena fishing vessels in Tanzania alone, although lake-wide data collection was overlooked because the economics of its value-chain paled in comparison to that of Nile perch. Despite that fisheries statistics are now monitored, much of fishers' catch and earnings go underreported (Onyango et al., 2021).

Omena was sold to traders, who dried, aggregated, and transported omena to regional markets around the lake and Zaire (now DRC) from 1987 through today (Gibbon, 1997b). Drying typically involved spreading the omena on a net on the ground to dry in the sun, sometimes using freely available bed nets that were intended for malaria prevention (Minakawa et al., 2008). Anywhere from a third to 100% of traders were women, depending on the region (Gibbon, 1997b; Jansen et al., 2000). Many haplochromid and small tilapia processors who lost their jobs during the Nile perch boom shifted to omena as its catches increased (van der Knapp & Ligtoet, 2010). Some wealthier women ran omena drying businesses, employing other women to conduct the labour-intensive process of trading and drying (Jansen et al., 2000). Most omena was sun-dried and exported to inland Tanzania, inland Kenya, or Zaire for commercial chicken feed, but a small portion of higher-quality omena was sold for human consumption (Gibbon, 1997b; Jansen et al., 2000). Between 1993 and 2008, consumption of omena had significantly increased while consumption of larger fishes had decreased (Eggert et al., 2015). Demand for omena for human consumption peaked in the dry season when other ASF were unavailable, suggesting its substitutability with other ASF and that it was a nutritionally important contingency (Gibbon, 1997b).

In the early 2000s, omena became the second most important fishery after Nile perch (Njiru et al., 2005). But because omena was low value and its contribution to food security was understudied and considered negligible, its fishery was largely ignored (Gibbon, 1997b; Jansen et al., 2000). Thus, national statistics on omena catch were unavailable, inconsistent, or inaccurate (Figure 3; Gibbon, 1997b). Researchers began examining the omena fishery to estimate sustainable harvest yields without threatening the valuable Nile perch fishery (Pitcher et al., 1996; Brown et al., 2005). Attention on omena fishery arose from concerns about ensuring Nile perch had prey: without

haplochromids, large Nile perch relied more heavily on omena (Pitcher et al., 1996). Indeed, omena biomass increased during Nile perch ‘bust’ periods due to prey release and seasonally in January/February due to environmental fluxuations and breeding habits (Tumwebaze et al., 2007).

Overall, the omena fishery remained abundant and underexploited (Pitcher et al., 1996; Natugonza et al., 2016) until around 2014, when significant declines in populations were observed (Yongo et al., 2018a). Over time, omena had experienced phenotypic changes as a result of Nile perch introduction, including decreased body size, smaller maturation size, and increased reproductive effort (Sharpe et al., 2012; Yongo et al., 2019). Fecundity increased, theoretically resulting from increased fishing pressure (Yongo et al., 2019). Various sub-populations emerged: smaller and faster-maturing fish observed in shallow near-shore waters differed from larger and slower-maturing fish in deeper waters (Mangeni-Sande et al., 2019). Recommendations on minimum mesh sizes and prohibiting near-shore fishing of omena aimed to sustainably manage the fishery (Yongo et al., 2018a; Mangeni-Sande et al., 2019). But the omena fishery remained inhibited from increased exploitation due to poor road networks and lack of cold-chain infrastructure (Witte et al., 1999). Thus, the local drying of omena to preserve it prior to transport to feed mills persisted as it was more profitable, although resulted in poorer-quality product (Witte et al., 1999).

The lack of cold-chain may have preserved women’s inclusion as omena dryers as they were increasingly displaced elsewhere (Jansen et al., 2000). Increasing intensification and commoditisation of the omena fishery for livestock feed had gendered consequences, where women were displaced by men in their role as traders in the omena value-chain (Witte et al., 1999; Jansen et al., 2000). Women traders remained, but operated locally and with smaller volumes. A small number of desperate fishers from the Nile perch industry transitioned to omena fishing during Nile perch bust periods (Jansen et al., 2000). As a result, women were pushed out by these men exiting the Nile perch industry (Pearson et al., 2013). While omena drying remained a female-dominated industry (Olale & Henson, 2013), processing jobs were insufficient to replace trading and processing jobs and many people became unemployed (Abila & Jansen, 1997). Many women abandoned independent trading due to the unavailability of fish (Abila & Jansen, 1997). The result was a highly gendered value-chain, where men owned boats and fished while women processed, trading locally but not in large volumes with feed mill operators (Nunan et al., 2018), possibly due to their inability to transport volumes and attachment to homestead activities.

Only one report provided some statistics on the omena value-chain recently (LVFO, 2016). Omena landings increased from 418,590 to 674,616 tonnes between 2010 and 2015 (LVFO, 2016). Of that, an estimated 30% was destined for human consumption in 2015 (in Uganda, only 20% was for human consumption; LVFO, 2016). However, this percentage resulted in significant intake per capita: Tanzanians around the lake ate an estimated 10 kg annually in 2015 (LVFO, 2016). Omena traders were comprised of 55% men and 45% women on average (LVFO, 2016). Women traders often reported participating in women’s groups (LVFO, 2016), but it is unclear how or to what extent these

groups directly or indirectly support trading activities. An updated and robust value-chain analysis of the omena fishery is warranted.

3.2.8 Aquaculture

While at first slow to develop, Lake Victoria's aquaculture is now rapidly growing (Aura et al., 2018). Aquaculture was first introduced in Uganda in 1953, aiming to stock fisheries and increase local protein supply (Balirwa, 2007). The first trials in Kenya in 1988 were quickly abandoned due to hyacinth overgrowth which damaged the cages (Aura et al., 2018). Domestication of Nile perch was desired but, unlike tilapia, failed to commercialise due to its live feed requirements and costs (Balirwa, 2007). Rather, tilapia aquaculture was encouraged for local consumption, income, and food security (Njiru et al., 2005; Balirwa, 2007; Njiru et al., 2008a). Wetland experiments on the Kenyan shores of Lake Victoria with integrated agri-aquaculture 'fingerponds' were successful at increasing fish and vegetable production and conserving wetlands (Kipkemboi et al., 2007; Kaggwa et al., 2008; Kipkemboi et al., 2010; Kaggwa et al., 2010) and are still operating today. Indeed, wetland conversion to agriculture was thought to more effectively reduce the nutrient burden to the lake (Simonit & Perrings, 2011). In Kenya, development projects promoted tilapia and catfish ponds away from the lake to improve inland fish availability (Oyieng et al., 2013). Over time, agricultural development in wetlands led to lake level recession and wetland degradation (Okotto-Okotto et al., 2018).

The private first cage culture operation in Kenya began production in 2005 (Aura et al., 2018). Cage aquaculture exclusively grew Nile tilapia for regional markets (Aura et al., 2018). Around 2015, large-scale commercial tilapia cage farms (Victory Farms, Africa Blue) set up operations in Kenyan waters based on similar production models in Zambia (see: <https://yalelo.com/> and <https://www.lakeharvest.com/>). These farms have increased production rapidly (Moran, 2023, personal comms). As of 2018, seven tilapia hatcheries existed (Aura et al., 2018), but most operations ran small cages (two by two-by-two metres) owned by smallholders and were located within 200 m from the shore (Aura et al., 2018). Their placement close to shore facilitated access, but with reduced circulation and cage bottom clearance, led to production issues and environmental consequences (Aura et al., 2018; Njiru et al., 2019). Poor management practices and placement of cages has led to concerns about the unsustainability of the industry (Njiru et al., 2019).

Considering the industry's rapid intensification, concerns about the introduction of Tilapia Lake Virus led to calls for management and diagnostic and outbreak response systems (Hounmanou et al., 2018). If sustainably managed, aquaculture was perceived as an economic boon to the Lake Victoria region, particularly considering the declining Nile perch industry (Njiru et al., 2019). The LVFO and Kenyan government have been active in creating spatial plans and suitability assessments for developing the cage farming industry in Lake Victoria (see: <https://sawa.blue/> and <https://lvfo.org/truefish-project-news>). Nevertheless, vast opportunities remain to augment the

literature on the current state of aquaculture across Lake Victoria. Only one ground-breaking article characterising cage aquaculture in the lake was identified, limited to the Kenyan portion (Aura et al., 2018).

Like fisheries, aquaculture is highly gendered, and women largely excluded. Kenyan tilapia cage culture was male dominated, in accordance with local customs prohibiting women from owning property (Aura et al., 2018). Women mainly engage in trade and value-added (fried) tilapia as ‘Mama Samaki’ fish vendors (as reported by key informants). Aura et al.’s (2018) passing stipulation that women are excluded but also uninterested in participating in the fisheries and aquaculture value-chains requires further investigation: women were previously more involved in beach fishing and trading, and successful interventions facilitating female-owned boats were successful. Are women ‘uninterested’ due to feeling unwelcome or excluded? Research on the degree to which and reasons why women are ‘uninterested’ and the motivations and impact of Mama Samaki vendors are warranted.

3.2.9 State of the Art & Research Questions

A large portion of the literature has explored the ecological and economic effects of the Nile perch industry on littoral communities of Lake Victoria. While articles in the first literature review described the role of fish in food security, those specific to Lake Victoria evidenced that the Nile perch industry did not translate to improved food security around the lake, mainly due to the influx of migrants to the area that drove down catch-per-unit-effort and diluted incomes. The review also identified gendered and economic inequalities within the fish value-chain. While articles on Lake Victoria described the region as food insecure, both qualitative and quantitative dietary assessments of communities reliant on fisheries are needed, particularly since the Nile perch export industry collapse; an updated qualitative and quantitative dietary assessment is included in this thesis. A small portion of the reviewed literature attested that, despite being low-value, other fisheries in Lake Victoria have cultural value and contribute to food security, yet have been largely ignored due to their low economic value, overshadowed by the Nile perch trade (Johnson, 2017). Thus, this thesis will focus on the contribution of omena and its value-chain, which has been so far understudied.

More recent literature has characterised the Nile perch fishery by its seasonality (peaking minorly in March and majorly in July) and small average body sizes (Yongo et al., 2018b). Ecosystem modelling and the state of fisheries has also been published (Aura et al., 2020; Natugoza et al., 2020a, 2020b). Additionally, it has explored eutrophication and pollution/contamination (Mwamburi et al., 2020; Egessa et al., 2020; Onyango et al., 2020), HIV and other disease interventions (Bbosa et al., 2020; Rosen et al., 2020; Tumwine et al., 2021; Kusemererwa et al., 2021; Kapiga et al., 2021; Ngingo et al., 2023), the technical efficiency of fishers (Mkuna & Baiyegunhi, 2021), lakeshore fish price determination (Sambuo et al., 2021), inequality between omena traders (but does not mention gender; Mkunda et al., 2020), and aquaculture technology potential (Clough et al., 2020; Berg et al., 2021;

Aura et al., 2021; Musa et al., 2022; Myakeya et al., 2022; Kals et al., 2024). Only one recent article has measured fish consumption in response to the COVID-19 pandemic (Fiorella et al., 2021), but not its role in the larger diet. Another measured dietary diversity, and subjective experience of food insecurity during the COVID-19 pandemic (Okronipa et al., 2023) but did not examine the specific role of fish. Nutritional and elemental composition of omena has also been tested (Clarke et al., 2022), but also was not contextualised in the wider diet. The literature review on Lake Victoria did not identify any publications examining household livelihoods and food security, nor that quantified the role of fish within diets. Thus, this thesis will examine the role of fish (not just Nile perch) on livelihoods and contextualised in broader diets using both qualitative and quantitative methods, considering gendered and generational nuances.

These literature reviews have provided our point of departure: overall, a post-Nile perch era assessment of Lake Victoria's food fish system and its impact on littoral communities' food security is needed. Therefore, this thesis will attempt to document a current assessment of the state of food security in Kenyan littoral communities and the role of fish within. Overarching research questions include: What has happened to littoral communities since the fall of the Nile perch export trade? What is the state of their food security, their livelihoods, and the role of fish within?

This thesis answers the following lines of inquiry, revolving around the perceived and nutritional value of fish, and provides an assessment of its cultural, livelihood and dietary contributions. The research questions answered are:

- How do different demographics feel about fish in their diets, food culture and food security?
- What role do fish play in traditional recipes and have those recipes persisted? Do fish still have cultural value as food?
- Through what pathways are people from different socio-economic groups accessing fish, and what are their barriers to fish consumption? What other barriers to nutrition security do they face?
- What micronutrients are being supplied through commonly consumed fish?
- Have preparation methods changed and how do recipes contribute micronutrients?
- What role do fish from fisheries and aquaculture play in the provisioning of livelihoods and micronutrients? Are cultured fish a substitution for, or supplement to wild caught fish, and how does that impact on micronutrient intake?
- How does the micronutrient contribution of fish compare to other commonly consumed foods? To what extent are fish a source of micronutrients, and does that vary between socio-economic class or generation?

Chapter 4: The Study Area

This chapter provides a description of the study area. As very little has been published on the littoral communities on the Kenyan shores of Lake Victoria since the collapse of the Nile perch industry and the birth of aquaculture, the information on the study area is drawn from my qualitative data that was collected during my fieldwork. Briefly, the study area description was obtained through my ethnographical observations, interviews, and focus groups, all of which are described in depth in section 4.1 before the study area description (notably, this qualitative work also informed the interpretation of my subsequent chapters, as described in chapter 5). Despite being derived from my fieldwork, this study area description is placed before the main methods chapter in this thesis so that the methodological approach can be understood in context.

4.1 Methods

Qualitative methods included semi-structured interviews, focus groups, oral histories with elders, and photovoice methods with youths. These were designed to access both genders across a range of ages and hierarchical positions within the community. Each activity is explained in the following sections.

4.1.1 Semi-structured interviews and focus groups

To characterise the study area, its food system, and its populations' food culture, I collected a series of discussions via face-to-face semi-structured interviews and focus groups. If only one or two people were available, an interview was conducted; if more than two people were interested in engaging with the researchers, a focus group was conducted. Sometimes, interviews would turn into focus groups. Conducting interviews in public spaces often attracted multiple people who were curious about and wanted to participate in the activity; it would have felt ethically inappropriate to ask them to leave and more inclusive to accept their voluntary contributions. While focus groups are traditionally designed to encourage interaction between participants (Bryon, 2016), my focus groups were more akin to interviews, allowing for, but not necessarily designed to prompt interaction between participants. Focus groups were purposefully used because they were a practical way of engaging with more informants of similar backgrounds and demographics within time resource limitations.

The aims and design of the questions borrowed conceptual frameworks from 'food scouting', which is described as

The ethnography-based documentation of folk/traditional perceptions, uses, and management of threatened or neglected plant, animal, and microbial food

ingredients used within a given cultural setting/community as well as the folk customs attached to them that developed within a certain area as the result of a long socio-ecological coevolution. (Pieroni et al., 2016)

Food scouting is “the study of the food-people-place nexus... the social, cultural, and economic dynamics associated with food production, exchange, and consumption” (Zocchi et al., 2023). Thus, the methodology aligned with food scaping to (1) characterise the foodscape in terms of diversity of foods, and (2) analyse the socio-cultural, economic, and culinary aspect of foods within the study area (Zocchi et al., 2023). Questions in the semi-structured interviews and focus groups aimed to inspire discussions on: locations and drivers of food production, distribution, and consumption; means of collecting, growing, or purchasing food, including income sources; traditions or taboos concerning foods; perceptions of food resources; changes in the food landscape over lifetimes; and differences in food landscape engagement between generations and genders.

In all cases, conversations were prompted using prepared and direct questions (Appendix 1), then continued with follow-up, probing, indirect, and interpreting/reflective questions throughout (Bryon, 2016). Two versions of the survey were used, depending on the participant type. Questions for informants who were in positions of power or oversight of the community (government officials, elders, and commercial industrial representatives) were phrased to entice generalities about the community whereas questions for civilians (subsistence farmers, fishers, fish processors, and heads of households) were phrased to encourage reflection on their personal habits and circumstances. Practically, factual type questions (e.g., “What types of foods are common?”) were used at the beginning and more polarising or emotionally charged questions (e.g., “How do you feel about the new fish farms?”) were used towards the end once more trust and rapport had been established.

This study interviewed purposefully selected informants and used stratified sampling methods to identify participants (Bryman, 2016). Stratified sampling means dividing the population into subgroups – in this case, the subgroups were key informants with oversight of the community as a whole versus key informants who would provide their personal experience. While similar studies only used elders as informants (e.g., Ogoye-Ndegwa & Aagaard-Hansen, 2006), participants in the present study were stratified by demographic (to engage government officials, commercial industrial representatives, elders, subsistence farmers, fishers, fish processors, and heads of households). The sampling was inspired by feminist ethnography to be inclusive of women’s experiences and perspectives often marginalised from research (Reinharz & Davidman, 1992; Bryon, 2016) and attempted to include both male and female participants across a range of ages.

The first group of interviews were with those who held power within the community, including government officials (BMU representatives, fisheries officers, politicians), elders, and commercial industrial representatives. It was imperative to engage with them first as gatekeepers to the

community. They were recruited using snowballing techniques, where interviewers asked participants for introductions to other potential participants (Bryman, 2016). While interviewers asked for connections to female officers and representatives, none materialised and all interviews for these groups were with men. While the focus group with elders did include two women, they refrained from contributing to the discussion.

Thus, the second stage focused on recruiting women participants exclusively to address gender imbalances, ensure their inclusion in the research process, and because women are responsible for cooking at the household level (Owino, 2019). Fishers and fish processors were recruited by visiting common areas for fish landing and processing and randomly inviting working women to join the focus group discussions. Some participants in these focus groups self-recruited. Engagement with subsistence farmers and households was generated randomly by visiting every third household in each village beginning from a random location on the main street until the quota was reached. At these households, interviewers requested and were unanimously granted to talk with the female heads of households in private. Participants were given the option to communicate in their preferred language, and a Luo-Swahili-English translator was present at all interviews and focus groups.

4.1.2 Oral Histories

This activity involved engaging with elders who were selected based on their willingness and interest. My methods followed those of the Oral History Association (2009). The purpose of an oral history was to capture in-depth personal stories and feelings; in this project, elders told their stories and feelings about food and food systems in the study area to obtain ‘food histories’ (Albala, 2009; Di Fiore, 2020). The first stage involved recruiting participants through door-to-door solicitation, as some older people in Sindo have limited mobility and no access to phones or email. After the potential participants chose the language they wanted to communicate in, the project was described and consent obtained and recorded. Translators were present at all events for real-time translation into English for the lead researcher. The elders were made aware that they could choose to pause the activity and continue the following day should they need to rest or continue with their daily activities.

In the second stage, aims and goals for oral histories were co-developed with the elders. The aims generally concerned understanding their experiences around food, particularly comparing when they were younger to now. The participants were asked a series of questions, which escalated in vulnerability and intensity as the conversation progressed. For example, the first questions were “What is your favourite fish? What is your favourite food? What types of foods do you eat? What are your favourite recipes?” with later questions including “What fish and/or foods do you wish you had more of? What is your favourite memory of fish and/or food as a child? How important is fish to you now versus when you were a child? Does your family experience any conflict around fish and/or food?”. These questions were semi-structured and emergent based on the aims of the elder

and their line of storytelling. After the conversation, photos were taken by the researcher, at the discretion of the participant and what they felt would be pertinent to the ethos and content of their stories.

4.1.3 PhotoVoice

A PhotoVoice activity was conducted with youths (aged 18-19), where they took photographs to illustrate important stories or messages concerning food systems and food security in the study area. Photovoice methods have been used elsewhere in rural Kenya (Kingery et al., 2016). The purpose of the project was to learn from youths about what problems and opportunities youths experience around food and food systems, and what solutions could support better experiences with food. The methods were based on the methods by Foster-Fisherman et al., (2010) on data collection and discussion (but not analysis and dissemination). In contrast to Foster-Fisherman et al., (2010), analysis was conducted by the lead researchers only. PhotoVoice could be considered a form of visual ethnography (Schwartz, 1989) informed by participatory action research, where the youths were asked to provide interpretation for the photos rather than the photos being interpreted by the researcher and risking misinterpretation or misrepresentation.

Six youths (three women and three men aged eighteen) were recruited by asking three different local high schools to identify potential participants. Similar to methods by Foster-Fisherman et al., (2010), potential participants were characterised by their enthusiastic engagement in scholastic activities and as having “untapped leadership potential”. The PhotoVoice activity required proactivity, creativity, and a desire to engage with the material. Including randomly selected youths for previous focus group activities in the study area resulted in many youths not engaging with the research process, either in a rebellious attempt to regain power in positionality of the group, out of noninterest, or lack of confidence. Working with students who were not top performers would have increased the risk of non-engagement.

Youths were selected based on their willingness and interest in participating. Using texting and phone calls, the youths collectively agreed on a meeting place. By attending the activity at the agreed upon time and place, consent was ensured. In the first meeting, the youths were given the information sheets and the project was described. Youths were given the opportunity to ask questions before signing consent forms. Participants, researchers, and stand-by translators then participated in a “ice-breaker” activity (Appendix 2). Youths were asked if they wanted to do an ice-breaker activity, then given the choice of three ice-breaker activities. The intention was to decrease the power differentials between the youths and the research team (Bryman, 2016).

In the first phase of the activity, project aims were developed, and youths were trained. First, the project aims were co-developed between the youths and researcher team, but generally revolved around the theme of describing local food systems and food security, its opportunities, its challenges,

and their hopes and dreams for the future. Other important aims for the youths were (1) networking and community-building, and (2) exposure to and development of research skills and data collection. Then, youths were introduced to the concept of the PhotoVoice activity and trained in how to take photos that illustrated stories, concepts, and key messages. Youths were encouraged to think of their stories, concepts, and messages and then searching for potential photographs that illustrated them.

Based on the aims, the youths were provided with guiding questions (a) “Where does your food come from?” (b) “What could you and your friends do to make food better?” (c) “What are some of the ways that local organizations and adults can help you make this happen?” and (d) “What are your dreams for the future?” Youths were also trained in how to use the disposable cameras provided and how to frame photos. The ethics of taking photos (e.g., ask people for their consent prior to taking their photo or a photo of their house or other owned items) were also reviewed. After one week, the cameras were collected and films developed.

After the films had been developed, a second meeting was scheduled with the youths (at their convenience and preferred location) to discuss the photos. Youths reviewed their photos and selected several to discuss. For each photo, they showed the photo to the group and described their story, concept, or key message behind the photo. The pursuing discussion was an emergent part of this research process. In some cases, the lead facilitator used prompting questions, such as “Why did you want to take this photo?” or “What is important for people to understand about this photo?”. Other youths had the opportunity to respond or add their own comments about the photo. At the end of the activity, the youths were asked to sign a media release form. They were also asked about their feedback on the activity.

4.1.4 Qualitative Analysis Methods

All activities were recorded, transcribed, and conducted in the language of the participants’ choosing and translators accompanied every event. If the participants preferred speaking in Luo or Swahili, English translations were carried out during the interview and included in the recording. While the interviews and focus groups were audio-recorded, the oral history and photovoice activities were video-recorded. For these activities, the participant was provided the opportunity to listen to the audio-recording and look at the photos to approve them and/or request alterations. At the end of the activity after the elders and youths had an opportunity to review the material, they then signed a release form that authorised the publication of the materials.

All transcriptions were analysed post-hoc using coding and thematic grouping methods in an interpretivist approach (Ryan & Bernard, 2003; Braun & Clarke, 2006). An interpretivist approach was used because the qualitative aims were to understand the state of food security from the subjective perspective of the participants themselves (Burns et al., 2022). Understanding the beliefs, perspectives, opinions, and lived experiences of informants was critical for identifying the subjective

experiences of food security in the area, an often-forgotten component of food security, overshadowed by dietary data and micronutrient compositions. While distinguished from the objective, positivist, quantitative work (Junjie & Yingxin, 2022), an interpretivist is compatible with and indeed should be used in conjunction with positivist methods to understand both subjective and objective elements of food security. Grounded theory development was inappropriate given the lack of purer ethnographic methods and ungeneralisability of the narrative beyond the study area (Burns et al., 2022). As a case study situated in a limited geography and my residence at the fish farm prevented complete immersion as would be expected in pure ethnography (Wolcott, 1990; Bryon, 2016), this work was unable to produce grounded theories or deeper ethnographic analysis (Alvesson & Karreman, 2011). Thus, interpretivist approaches using questions and observations were engaged to generate a rich and detailed understanding of the study area's food systems and the role of fish within in and assess the subjective experiences of food security in the study area.

During the first stage of analysis, semantic 'in vivo' coding was employed to retain participants voices and lived experiences throughout the research process (Saldaña, 2021; Musyoka et al., 2023). As transcriptions were coded, analytic memos were used to detail ideas, reflections, or salient themes arising during the coding process to facilitate the second cycle coding phase. During the second stage, latent thematic analysis of codes was conducted to develop secondary codes, primarily generated through identification of repetition, comparisons, and linguistic connectors (Ryan & Bernard, 2003). By filtering primary codes by their secondary codes, core themes were developed based on semantic content and informed by data from the observational methods (Wæraas, 2022). Practically, primary codes were listed alongside their secondary codes in a Microsoft Excel sheet for manipulation and grouping exercises. An interpretivist narrative resulted, describing the local food system and food security as viewed by the participants over their lifespan (Burns et al., 2022).

Thematic and narrative analysis generated themes in two main categories: (1) descriptive codes characterising the food system and (2) sentient codes explicitly reflecting participants' perceptions, feelings, and opinions. The organisation of this section mirrors the categorisation, beginning with a description of the local food system, followed by local perceptions on food security arising from the sentient codes. Separately, the codes from the oral histories and photovoice stories were converted into poetry using in vivo dramaturgical coding methods and paired with the photos. Youths' photographs were paired with poetry derived from the stories assigned to each photograph. While elders directed us to take a variety of photos, they were not involved in pairing the photos with the stories. The poetry was printed for the participants, and their consent was obtained before [the book was published digitally](#) (Pounds et al., 2024).

4.2 Results: Study area description

The study area is located on the Kenyan shore of Lake Victoria, which is co-governed by Kenya, Uganda, and Tanzania. Lake Victoria is the largest freshwater lake in Sub-Saharan Africa, with an

area of 69,295 square kilometres (Awange et al., 2019). It is an important freshwater resource for Kenyans, supporting sectors like fish production, water extraction (drinking and irrigation), tourism, wildlife, and transportation routes. Its fisheries sector particularly has been affected by anthropogenic activities, including climate change, irrigation, hydropower (Awange et al., 2019), the introduction of invasive species (Taabu-Munyaho, 2016), and overfishing (Nyamweya et al., 2020). The Lake's water level fluctuates (Swenson & Wahr, 2009), causing livelihood challenges for littoral communities (Musoke & Boon, 2013).

More specifically, the study area is located in Homa Bay County, formerly known as the Nyanza Province and one of the five Kenyan counties that boarder Lake Victoria. This area has four seasons: two hot rainy seasons (Nov-Dec and Mar-May) and two cooler dry seasons (Jan-Feb and Jun-Oct; Gitau, 2012). Air temperature in the area ranges from 17 to 35 deg C and do vary considerably throughout the year (GoK, 2013). The landscape around the lakeshore is semi-arid and mountainous. Populations in Homa Bay County are predominantly from the Luo tribe. Most of the Homa Bay County's population is engaged in agriculture (74%), but 53% of the population lives in absolute poverty and 84% do not have enough food to meet their needs throughout the year (MoALF, 2016). However, this statistic is outdated considering it was estimated before the collapse of the Nile perch industry (see Figure 8), and largely unhelpful for my study because it is unsubstantiated in rigorous quantitative assessment of diets in the area. Most farming is rainfed and low production, with only 18% of farmers having access to irrigation (MoALF, 2016). The fishing communities around the lake have extremely high rates of HIV infection, reaching 37% in Homa Bay (Kwena et al., 2019).

The study area is centred on the rural town Sindo and includes all communities within a 5 km radius, but focused on villages Roo, Ragwe, W'adianga, Masaré, and Nyakwara as sites with higher population density (Figure 9). This study area was selected by identifying all villages within a 5km radius of the fast-growing cage aquaculture site. This was a practical decision: due to the funding mechanisms (more about these mechanisms are explained in section 5.5 and 5.6), I was based at the aquaculture site and needed to be able to travel for fieldwork within a day. Tilapia cage aquaculture in the study area began in 2017 and now supplies both urban and rural markets (Kaminski et al, in prep). In the study area, one fish farm exists (Victory Farms) and is now the largest fish farm in Sub-Saharan Africa, funded by significant international investment. Growing rapidly since its inception in 2015, it produced 30 tonnes of cage-cultured tilapia daily as of 2022. It employs over 600 people at its production site alone, with additional employment throughout its distribution and sales operations. It is fully vertically integrated and supplies tilapia across Kenya in its branded branch stores. Although it sells fish directly to consumers, its main customer is "Mama Samaki": women tilapia vendors who purchase tilapia in bulk and resell in markets, often value-adding by frying the fish into a convenient, ready to eat product.

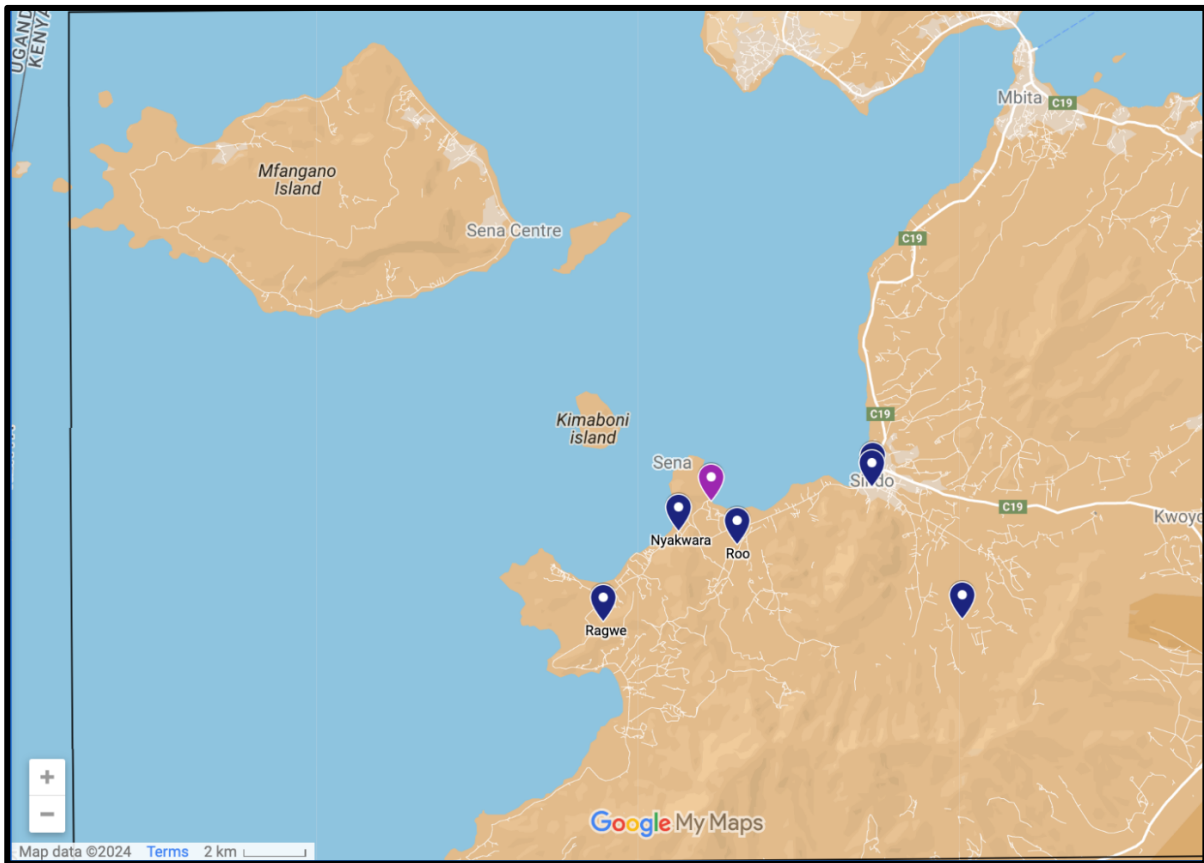
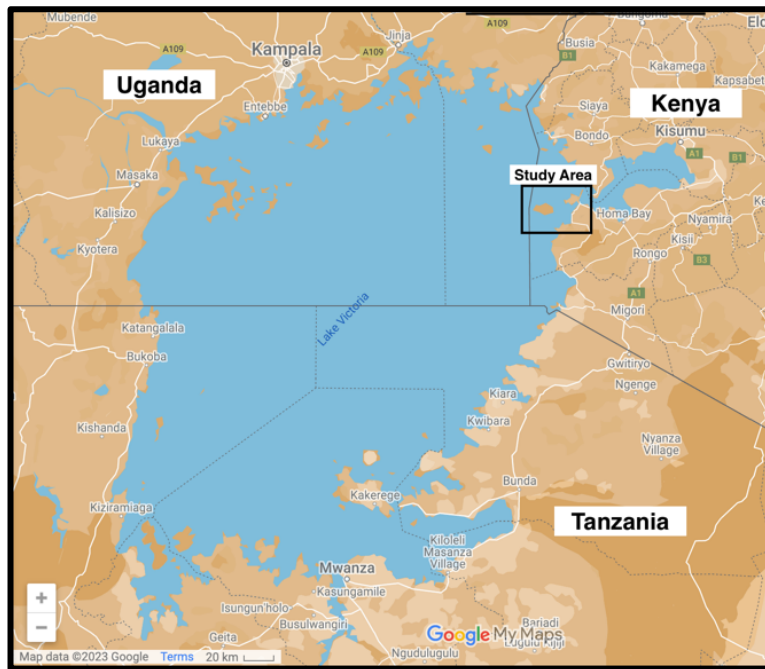


Figure 9: Map of the study area, including pin drops for villages included in the study. Dark blue pin drops indicate the primary villages and the purple pin drop indicates the nearest commercial-scale cage aquaculture site.

The respondents described their population as fairly homogenous: the vast majority of inhabitants were of Christian denomination and of Luo ethnicity. This contrast with other ethnographic studies on the Tanzanian side describing diverse populations (Allegretti, 2019). Many people believed in ‘juok’, which translates to “soul” or “spirit” which is part of indigenous religious beliefs. Additionally, a wide range of Christian denominations were present. Various Christian sects were

listed and while Islam was also listed, some respondents qualified that they didn't know any Muslims personally. Certain religions in this area can have specific dietary rules, also found by Owino (2019) and Musyoka et al., (2023); for example, Muslims and certain Christian sects like the Nominya church cannot eat fish without scales, such as catfish. Respondents generally categorised their population by distinguishing church-goers from non-church goers, rich from poor, old from young, and men from women.

Polygamy was widely practiced, although each wife had her own home in which to raise her children. Luos also practice sororate polygamy, where a man can marry women who are sisters and marry their deceased brothers' wife to ensure continuation of the lineage (Nyambedha et al., 2003). In the present study, women reported that they generally migrated into the study area from their homes to marry local men. Nyambedha et al., (2003) and Prince (2008) also described that Luos practice polygamy, exogamy, and virilocality. Upon the death of a married man, his wife(s) may become an "inherited wife" of their late husbands' brother to retain patrilineality (Nyambedha et al., 2003; Prince, 2008); however, women in the present study noted a more recent ability to refuse re-marriage. While a family consisted of a man and all his wives and children, households were defined as "those living under the same roof and eating from the same pot." Generally, everyone in a household shared food from a common pot prepared by the female head of each household (i.e., the wife). In polygamous families, this occasionally included the husband who split his time and income between households. Generally, wives depended on their husband's income, but would create their own businesses to offset their reliance. Polygamy was considered important in light of the high HIV/AIDs prevalence. Women in the present study noted that polygamy was better than monogamy because it limited the risk of disease transmission: "a polygamous man will be with my co-wife when I am here doing my business. If the man is on the other side with no wife, it's danger." In contrast, women in polygamous fishing households in Malawi felt negatively about polygamy because they were forced to share income with their co-wives (Manyungwa et al., 2019), The role of polygamy in livelihoods and food security warrants investigation, but it beyond the scope of this thesis.

Key informants stressed the reliance of the local community on the lake and its resources. Indeed, one politician described: "The lake is their source of survival." Its critical resources included fish for food and money as well as for drinking water, irrigation, transportation, etc. Historically, the lake supported all aspects of life: it was a means of transportation in the absence of road networks, and a source of food and water for drinking, livestock, and bathing. Since piped water is unavailable, drinking water is obtained by filling pails, buckets, and/or jerrycans to transport water to homes. Water was carried on heads or on donkeys. Some people pay for water delivery services, where large containers of lake water are delivered to houses using donkeys and carts. They mentioned that public taps were installed several years ago, but many people lived closer to the lake than to a public tap. Many people boiled and/or added chlorine solution to water intended for drinking. However, many people would drink water directly from the lake, which increased their risk of water-borne diseases,

particularly since most people bath themselves and clean their household items, livestock and their vehicles directly in the shallows of the lake where water is being extracted.

The main income-generating activities in the area are visualised in Figure 10. The market was noted as particularly important for generating income and supporting wellbeing, being the main location where people sourced food and household items.



Figure 10: A sketch drawn by friend and artist Jenn Paratje depicting the study area and the variety of income-generating activities: (a) off-shore fishing, (b) beach set net fishing, (c) banda (fish trading) operation, (d) omena aggregation & trading, (e) omena fetching (carrying omena from the boat to the omena drying fields), (f) omena drying, (g) crop farming, (h) crop sales, (i) fish and omena market sales, (j) used clothing sales, (k) kiosk, salon, or restaurant (making chapati, fried mandazi breads, and porridge) businesses, (l) gas station and fishing auxiliary services (mechanics, fishing equipment sales and repair), (m) MPesa communication & banking services, (n) fish frying/smoking business, (o) lake water delivery services, (p) bodaboda (motorcycle taxi), (q) poultry farming stonemaking and sand mining, (s) employment at fish farms, (t) firewood fetching, (u) charcoal making. Not pictured here: government pension scheme for the elderly and manual labour (e.g., digging).

Table banking was also considered important financial/social capital, as found elsewhere in Kenya (Coppock & Desta, 2013). Table banking was a collective-action savings group (Coppock & Desta, 2013). Key informants described table banking (also known as “merry-go-round”) as a group of women who made monthly contributions to the group, and the lump sum was either given or loaned to a particular group member each month. This enabled the recipient to purchase more expensive items, such as livestock or equipment (e.g., sewing machines). While most table banking groups were initially formed informally by a few female friends or neighbours, the characteristics of table banking varied significantly: some groups remained informal and small, with only three or more members, whereas other table banking groups had over 150 members and membership was contingent on a rigorous application process. Regardless, these groups were entirely indigenous without outside actors involved. Additionally, table banking members were usually women, and very few men participated (see also: Geheb et al., 2008). The main benefits to table banking were improved access to large cash sums and loans; the main challenges with table banking were reliability and honesty of the assigned treasurer. In the continued absence of banking institutions and lack of alternative ways of building assets that are easy to cash in, women participated in table banking whereas men tended to invest in livestock as a form of capital investment. While table banking was highlighted as an important source of cash for women in the study area, it was not the main focus of this thesis and additional research in this study area is warranted, although informal credit groups are common elsewhere (Wickrama & Keith, 1994; Cherotich et al., 2021; Gichuki & Kamau, 2022; Muthini & Ndede, 2022).

4.2.1 Food habits and commonly consumed foods

Key informants reported that the most commonly consumed dishes were uji (porridge), ugali (a stiff maize dough), omena, and indigenous leafy green vegetables. Uji, sometimes paired with cassava or sweet potato, was a staple for breakfast and/or lunch, as found by Smart (2017). Uji was made from maize, millet, sorghum and/or other grains, along with milk and sugar if affordable. As one woman noted, “I add sugar to uji if I can afford it.” Some people fermented porridge overnight before cooking it the next morning. Uji for infants was often supplemented with powdered omena, groundnuts, and/or margarine. Corn, a mixture of potatoes and rice or nyoya (the Duluo word for a mixture of corn kernels and beans, known as ‘githeri’ in Swahili) were noted as a common lunch dishes. In addition to these foods, tea was an important beverage, often served with milk and sugar if affordable and used as a meal substitution for people unable to afford three meals daily. Smart (2017) also found that milk and sugar in tea on the marine coast of Kenya was limited by affordability. In contrast, fruits were perceived as an occasional snack food and not a staple in the diet. If a person craved fruit, they would pick it directly from their tree. Fruit was also viewed as supplementary to the diet if the consumer was sick; for those without land, fruit was purchased from markets.

Dinner was the main meal, ideally consisting of an animal source food (ASF), a leafy vegetable, and ugali, as also described by Ebere et al., (2021). The importance of ugali was emphasized, with many men laughing that “A meal without ugali is not a meal for a Kenyan!” Owino (2019) also found that a meal consisting of fish and ugali was associated with Luo culture in Kenya. Ugali was also a staple in Tanzania, although people preferred rice in contrast to the present study (Moreau & Garaway, 2018). Key informants often said that “Kenyan men eat ugali”, where ugali symbolised patriotism and masculinity. While ugali was a consistent staple regardless of gender or wealth, either the vegetables or ASF would be sacrificed if both were unaffordable. The leafy green vegetable dish consisted of locally grown indigenous leafy green vegetables (Atek or *Dyschoriste radicans*, apoth or *Conchorus trilocularis*, osuga or *Solanum nigrum*, sukumawiki or *Brassica oleracea var. viridis*, etc), locally grown kales, or imported cabbage. Luo consumption of these vegetables were also described by Ogoye-Ndegwa (2003). Apoth (*Conchorus trilocularis*) was mentioned frequently by most respondents in the present study, although other studies have noted that it is viewed as food for the poor or for weaning infants because it’s slippery when cooked (Ogoye-Ndegwa & Aagaard-Hansen, 2003). Regardless of the species, the leafy green vegetable was always cooked separately from the ASF. For those with digestive issues or cooking for very young children or the elderly, baking soda was used to soften vegetables and citric acid was added to porridge to thicken it or give it a slightly sour flavour compared to fermented porridge. While over 70 different species of wild vegetables are traditionally consumed by Luos and contribute to nutritional security, meat and fish are more favoured over vegetables (Ogoye-Ndegwa & Aagaard-Hansen, 2003).

The most commonly consumed ASF was sun-dried omena because it was cheap (Table 3). Previously, key informants described drying and consuming haplochromids; in their absence, omena has assumed their role in local diets. Tilapia and Nile perch were not easily dried and thus did not offer an easy substitution for haplochromids. Today, one haplochromid species was still dried and consumed (‘fulu’ in Duluo, *Haplochromis nubilus*), but not nearly in the same quantities or frequency as omena. Musyoka et al., (2023) also found that omena is considered a low-value food in Kenya. In Uganda, omena (known as mukene) was low-grade and mainly used as animal fodder (Beuving, 2019). Cheaper ASFs also satisfy preferences for ASF in other areas of Sub-Saharan Africa (Bukachi et al., 2022). Key informants described that fish, beef, and mutton were also commonly consumed. Chicken was rarely consumed and pork widely unavailable due to a swine disease outbreak several years prior. Termites were rarely consumed due to availability but were favoured for the large quantities of oil they released when cooked. In contrast, omena and fish were ethnically important and their consumption characterised Luo identity. Luos are considered “professional fish eaters” by other tribes, and indeed, dried omena are important for Luos across Kenya (Volpato & Ellena, 2023).

Table 3: Key informants’ estimates of animal source food prices in Sindo.

Animal Source Food	Estimated price (KSh per kg)
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Broiler chicken	600
Local chicken	800
Nile perch	370-400
Wild tilapia	370-400
Farmed tilapia (200g)	390
Farmed tilapia (400g)	375
Omena (dried)	50-175
Beef	500
Eggs	825-935 (15-17 per egg)

While omena was the most commonly consumed ASF because it was cheap, people preferred other fish species. Omena was almost exclusively sold dried while other fish were sold fresh. Key informants in the present study said they preferred Nile perch and tilapia because of its perceived health benefits as cholesterol-free protein source, which has been supported in the literature (e.g., Alhassan et al., 2017). When prompted, they agreed that omena was also nutritious, but not as “sweet” as the larger fish. One group of men agreed that “those who consume fish live longer” and estimated that 85% of the consumed fish (Nile perch and tilapia) come from the lake, whereas 15% comes from a local fish farm (all tilapia). Generally, Nile perch and tilapia were descaled, gutted, and cooked whole. Portioning Nile perch and tilapia occurred during serving, although key informants explained that ideally, each family member would have a whole fish on their plate. Thus, people preferred to have smaller, but many fish rather than one or two larger fish that would need portioning.

Little intergenerational variety in diets existed because household members ate from the same pot. Generally, household members over the age of six ate the same dishes. Newborns were exclusively breastfed until six months, at which point soft foods like porridge, rice and potatoes were introduced. At around one year old, omena, other fish species, ugali, and other common dishes were introduced. Omena were fed and consumed whole, whereas parents picked other fish species flesh from the bones for children between the ages of three to five years old, after which, children could eat independently. This contrasts with weaning practices in Tanzania, where children were given fish broth poured over ugali only and only adults received a portion of fish (Moreau & Garaway, 2018). Elders continued eating from the same pot of food as the household, although households would boil foods or add baking soda/citric acid to dishes to enhance food digestibility for elders.

Whereas other fish species and other ASF were usually cooked from fresh, omena was usually cooked from dried. The few key informants who purchased fresh omena would dry it themselves prior to cooking. Dried omena was generally eaten whole or simply with the head removed. Consumers would often remove the heads because of quality issues, where sand and dirt was lodged in the gills and completely removing the head was more convenient than attempting to clean the tiny

gills. In contrast, only the skin, flesh, and eggs of other fish species was consumed. Larger bones were discarded and guts were fed to livestock.

The most common cooking methods were boiling and frying. For omena, some women would boil then fry it. With the exception of rice, potatoes, and nyoya, which were simply boiled, animal source foods and leafy vegetables were usually fried plain (“dry fry”) or with tomatoes and/or onions (“wet fry”, Figure 11). A few people preferred adding milk to their leafy green vegetable dish. Some people noted that they would make soup with the ASF instead if they had time. Other fish species were only dried when there was a surplus of catch, or smoked during the rainy season. It was noted that while smoking is traditional, only fish that was no longer fresh would be smoked as a salvage strategy and smoked fish was not common practice due to its fuel requirements (see also Riedmiller, 1994). In contrast, people “don’t need anything for drying”. Other fish species were smoked on top of an “altar of wood... with wet leaves to ensure the fire isn’t inferno.” Only one wealthier woman said that she occasionally salted other fish species. Their decision to mainly fry was in the interest of convenience and cost: frying used less time and fuel.



Figure 11: A traditionally prepared meal of wet fry tilapia with ugali.

These consumed foods and cooking methods were consistent throughout the year. Special meals were cooked when receiving special visitors and on Christmas day, also found by Owino (2019). Musyoka et al., (2023) also found that rare or more expensive foods were cooked for visitors and on religious holidays. In the present study, slaughtering a chicken was frequently mentioned as custom for these particular events. Most people reported eating chicken for Christmas. Chicken specifically was also found to symbolise social unity and appreciation between urban- and rural-dwelling family-members (Owino, 2019). This present study found that mutton, beef, chapati, rice, potatoes, nyoya were also listed as common Christmas foods. In addition, key informants noted that the quantity mattered,

where large quantities of food were cooked to be shared among households. As one better-off woman in Sindo said, “For Christmas, you have to COOK my friend!” [emphasis hers].

Key informants did not identify any traditions around eating, besides praying and washing hands. With further prying, it was apparent that while breakfast and lunch were eaten at peoples’ place of work, dinner was a family affair. At dinner, everyone sat together and were served from the same pots of food and lumps of ugali. As one woman in a hillside agricultural village noted, “I wait for my husband to come back and eat.” Traditional Luo food folklore frames women as waiting at home with the children for men to return with food for the women to cook (Ogoye-Ndegwa & Aagaard-Hansen, 2006).

Key informants described that people provisioned food mainly through food purchasing. Both poorer and wealthier women estimated that they purchased at least 95% of their food, either foraging or growing the remaining 5%. The poor relied on foraged vegetables and/or cheap omena to accompany their purchased maize for ugali and porridge. Key informants detailed that bartering – locally known as the “butter trade” – used to be common but was now rare due to the commoditisation of the food market. Owina (2019) also reported that people provision food through purchasing, foraging, and bartering.

In summary, diets were monotonous and limited by food unaffordability because most food was imported into the study area. Local agriculture technology that could enable intensification and diversification was lacking and significantly limited local food production. Local foods were limited to forageable indigenous leafy green vegetables, fish and omena, and maize-based ugali and uji (porridge). Omena was ubiquitously consumed due to its affordability as an ASF. Indeed, the poor were most limited in their food choices. They were forced to choose either an indigenous leafy green vegetable like sukumawiki (*Brassica oleracea* var. *viridis*) and apoth (*Conchorus trilocularis*) or omena accompaniment to their ugali, whereas the rich could afford combinations and options. Leafy green vegetables were sold by the ‘bunch’ for 30 to 40 KSh. One ‘bunch’ was a suitable quantity for one person if the meal included other ASF accompaniments whereas meals with only ugali and vegetables required 2 bunches, or 60-80 KSh per person. The price of omena for one serving varied from 25KSh to almost 90 Ksh. The price of indigenous green vegetables and omena both varied seasonally, such that omena was cheaper than the vegetables at some times and vegetables were cheaper than omena at other times. While leafy green vegetables were available in markets, an array of indigenous leafy green vegetables were easily grown in small kitchen gardens and forageable (as discussed in greater detail below; see also: Ogoye-Ndegwa & Aagaard-Hansen, 2003), thus accessible even without cash for purchasing. The lack of variety and diversity has food security implications. Monotonous diets may limit their nutritional adequacy, which will be explored in the upcoming chapters. Because families ate from the same pot, gendered and generational differences in food intake are unknown; this will be examined in the following chapters.

4.2.2 Land-based agriculture and its commercial orientation

Farming was considered a major livelihood activity and was commercially oriented. Most households farmed, either on owned or rented land. Even among fishers, many also farmed. As early as 1997, farming was becoming increasingly important to fisher households on the Kenyan shores of Lake Victoria, but plot fragmentation and droughts resulted in low crop yields (Geheb & Binns, 1997). Most households provided their own labour for farming activities; however, wealthier people could afford to hire labour. In Masare, which was the furthest village from the lake, wealthier people from outside the village rented land and employed labourers in crop farming. This business arrangement was not apparent in other villages; however, Owina (2019) described that both freehold and leasehold tenure arrangements exist along the Kenyan shores of Lake Victoria, and land ownership is associated with social status, where lack of land ownership is associated with poverty.

Two types of agriculture were practiced: kitchen gardens and crop fields. ‘Kitchen gardens’ were used for growing vegetables for household consumption, including many indigenous leafy green vegetables. Kitchen gardens were located at the homestead, managed by the female head of household, and primarily contained small subsistence crops. Kitchen gardens mainly grew fruit trees and/or indigenous leafy green vegetables, the latter of which were considered staples in local diets alongside ugali (a maize, millet, or sorghum-based dough). In contrast to kitchen gardens, ‘crop fields’ were used for growing cash crops, mainly maize, sorghum, millet, and legumes (Figure 12). Occasionally, tomatoes and onions were grown as cash crops, although these crops relied on irrigation whereas most homesteads relied on rainfed agriculture. It was noted that most people grow maize. Crops were planted twice annually, in March and August. Crop fields were more common than kitchen gardens. Likewise in urban Kisumu, the poor were mainly motivated to farm cash crops to supplement their income (Owino, 2019). A list of the foods grown in the study area as reported by the participants is shown in Table 3. Other authors similarly described that Luo food crops included millet, sesame, sweet potato, yam, pumpkin, beans, and green grams (Ogoye-Ndegwa & Aagaard-Hansen, 2006). In Lugari district, maize and then cassava dominated crop portfolios, while sweet potatoes and white potatoes were an important supplement since they are drought-resistant and can be stored for up to six months (Djurfeldt & Wambugu, 2011).



Figure 12: Two Elders who participated in the Oral History activity stand in front of their maize crop in an agricultural village outside Sindo.

Table 4: List of foods grown by participants in their kitchen gardens and/or crop fields.

Fruits	Vegetables	Grains & legumes
oranges; mangos; papayas; lemon; avocado; bananas; plantains; guava; pineapples; limes; watermelon; passion fruit	onions; tomatoes; carrots; bell peppers; cabbages; kales; indigenous leafy green vegetables (apoth, kunda, susa, dek, sukumawiki, boh, mbogus)	beans; green grams; millet; cowpeas; potatoes

Key informants recounted that crop production had shifted from primarily millet and sorghum to maize over the last 40 years, with consequences for food security. This shift was associated with increased hunger. While sorghum has been the Luo's main historical staple food, maize replaced sorghum as the stable food crop in the 1930's (Ogoye-Ndegwa & Aagaard-Hansen, 2006). Between 1961 and 2009, global abundance of sorghum, cassava, millet, yams, sweet potatoes, and groundnut has relatively decreased while that of maize has increased (Khoury et al., 2014). Key informants in the present study described that millet and sorghum used to be the main cash crops and could be milled by hand at the homestead. Thus, a small portion could be retained for household consumption. In contrast, maize is firmer and must be mechanically milled; ergo, maize for consumption was entirely purchased, and at a higher price than it was sold to the millers. Millers were not interviewed and miller margins are unknown. Maize was also equated with hunger because it is 'lighter' than sorghum (Ogoye-Ndegwa & Aagaard-Hansen, 2006).

Crops were mainly grown from purchased seeds; however, seeds were often retained from the previous year's crops as back-ups in case seeds were unaffordable. Purchased seeds were considered superior to retained seeds, which would often become damaged or mouldy. Indeed, very few people believed seeds were too expensive. Rather, poor rain patterns and crop damages were the main challenges experienced with crops (Table 5). Fencing was required to protect crops from roaming livestock (see below). Price was also cited as a major challenge: prices were highly elastic and decreased with surplus harvesting. Generally, income from crop farming was considered inconsistent and unreliable. For this reason, some people did not see benefits to renting land for agriculture. Some people referenced climate change and increasingly unpredictable rain patterns as a major difference that affected crop production. One person said, "the fruits of my labour have gone down."

Table 5: Percentage of respondents reporting each challenge with crop farming.

Type of Challenge	Percent of respondents reporting the type of challenge (n=100) (multiple responses allowed, i.e., select all that apply)
Crop damage	87%
Poor rain patterns	86%
No irrigation	72%
Poor seeds	27%
No access to fertiliser	25%
Fertiliser expensive	23%
Equipment expensive	21%
No access to equipment	18%
No access to seeds	15%
Seeds expensive	15%

Both officials and the community feel that they lack technical agricultural knowledge (e.g., how to intercrop) and money for investing in agricultural technology. The agricultural technology is basic: seeds are often planted by hand without plows or mechanised equipment. People explained that they did not have enough money for irrigation. Mainly due to the lack of irrigation, local food production was insufficient and key informants described that the majority of food was imported from other areas. Most of the produce in the main market was sourced from the neighbouring county Kisii due to the produce deficit in the study area. Key informants lamented that the area lacked sufficient agricultural production for export to other regions, which they viewed as having a higher willingness to pay and a more reliable demand. Key informants, and particularly youths, indicated a need for improved road and transport networks that were resilient to weather conditions to improve access to local and regional markets.

Concisely, agricultural production was commercially-oriented rather than subsistence-based. Furthermore, crops had become increasingly commoditised in the past 20 to 30 years. With commoditisation, farmers shifted from producing crops that could be retained for household consumption (like millet) to crops that required additional processing off the homestead (mainly maize). This shift had negative implications for food security, where farmers were no longer able to fall back on crops during lean or poor cash-flow periods. Despite commercialisation, agriculture production significantly lacked technology, limiting its production. Additionally, poor infrastructure (e.g., fencing, roads) were major challenges to their productivity. These factors significantly limited farmers income-generation potential and threatened their ability to afford food. The role of kitchen gardens in food security – and whether they have changed to compensate for commoditisation of larger crops – warrants further study.

4.2.3 Foraging: a critical food security practice

Foraging was an important part of the food system. Key informants reported foraging for indigenous leafy green vegetables, mushrooms, kwasapota (a fruit), and insects for consumption, grass for livestock, and firewood for fuel. Ogoye-Ndegwa & Aagaard-Hansen (2003) also found that apoth (an indigenous leafy green vegetable, *Conchorus trilocularis*) was both foraged and grown in kitchen gardens. While foraging occurred year-round, only foraging for insects was seasonal, occurring only during the rainy season when rainwaters flush the insects (mainly termites) out of their colonies. Insects were cooked dry until their oils were released and their wings fell off, then consumed with ugali. Additionally, firewood and charcoal from foraged wood was the predominant cooking fuel used in the study area, as also found by Meru and Kinote (2021). Very few people used gas because it was considered expensive. Generally, people preferred using firewood, but would use charcoal if they lacked time. Nile Perch and tilapias were often caught by children (Figure 13), using a hook and line from shorelines. Even in no-fishing zones, children fishing recreationally are largely ignored by fisheries enforcement. Similarly, one key informant explained that people used to hunt small local antelopes and other game but now, it was illegal. He confided, “people still do it, they do it in groups, but not me.” These anecdotes suggest a potential phantom economy that was not shared with the research team due to its illegality, and it worth additional research.



Figure 13: A girl shows off her catch of the day, which she caught using a stick, fishing line, and a hook, standing by the lakeshore. She was going to give the fish to her mother to cook for dinner.

All but the richest people in the study area foraged. Some foraging was opportunistic, occurring for example while a youth was herding cattle and picked a few kwasapota. Others foraged purposefully. For example, some people operated a charcoal business, where they would venture into the mountains to collect firewood and burn it into charcoal for sales. Key informants explained that while women foraged for firewood, the charcoal business was male dominated because of the danger involved in burning the wood and the potential for runaway fires. Particularly for firewood foraging and the charcoal business, people alluded to land access conflicts. During a discussion with women in a table banking group, one woman said, “we collect firewood from anywhere”, and another immediately followed with “we cannot collect firewood from someone’s land,” creating a heavy pause in the conversation. In addition to land access conflicts, politicians noted that deforestation resulting from the charcoal business increased runoff into the lake and worsened water quality. They noted that “people need sensitisation”. Yet, raising awareness of the impact of deforestation may not be the only intervention required, because, while most people participated in foraging, foraging was disproportionately important for the poor. In the absence of physical (land, equipment) and financial (cash) capital, the poor relied on foraging as environmental capital for their livelihoods. This was

evidenced by their willingness to participate in the illegal and dangerous charcoal business. The poor's dependence on foraging was not limited to firewood: while indigenous leafy green vegetables grown in kitchen gardens were consumed and/or sold in local markets, those without land or cash relied on foraging these vegetables for subsistence purposes.

Thus, foraging was critical for food security: both indigenous leafy green vegetables and firewood were foraged and essential for direct food provisioning and income-generation for the poor. The decreasing availability of foraged foods threatened food security in the study area, particularly for the poor. In light of food commercialisation trends, improving the poor's ability to purchase food would theoretically improve their food security, relieve pressure on natural resources, and avoid land conflict issues.

4.2.4 Livestock as savings

People reported owning a variety of livestock, including hens, ducks, goats, cows, and sheep. The number of livestock varied greatly, and wealthier people were more likely to have bigger (i.e., cows instead of chickens and goats) and more animals. Pigs were absent in the study area because the government exterminated all pigs due to disease issues several years prior (in ongoing communication, translators have reported that some pigs have been reintroduced into the community since the time of these interviews). Livestock were raised to be sold, acting as a form of savings for the household, as found in the 1990's (Geheb & Binns, 1997). Larger animals were thus higher value. Their purchasing as juveniles was only affordable by richer people; poorer people raised chickens, which did not require any investments since they bred independently. Indeed, most chickens were a slower-growing local variety rather than the faster-growing broiler strains. Income from livestock was generally considered more reliable than income from agriculture. While livestock was mainly described as a form of cash savings (as found by Kipkemboi et al., 2007), chickens and ducks were occasionally slaughtered for subsistence purposes on Christmas day or for an important visitor. Livestock were mainly allowed to graze freely or, in the case of larger animals, accompanied by a member of the family (Figure 14). Grazing livestock ate grasses and wild plant life, but would also sometimes graze on unfenced crops, causing crop damage and social conflict. Regarding grazing and foraging, property laws appeared to be a contentious subject. Some people believed that the general public has the right to access public and private land for foraging and grazing – a value upheld by traditional governance systems (i.e., Chiefdoms) and culturally critical to the migratory Masai ethnic group, who herded cattle across Kenya; other people asserted that private property was now inaccessible. This conflict was a clear example of an area where traditional governance systems were still respected despite democratic systems also established. Those who adhered to new laws or who did not have anyone to accompany grazing animals practiced 'zero-grazing', where larger animals were tied in place using a rope around their necks, attached to a stick buried into the ground; each day, they would be positioned in a new area to access grasses and naturally occurring foods. In

contrast to livestock, donkeys, dogs, and cats were owned for their services rather than as cash savings. Donkeys were used for carrying water from the lake or equipment and for agricultural labour. Dogs were used for security, and cats were used for pest-control against monkeys and rats. However, pets were useless against weevils, which damaged crop and seed stores. Like crops, livestock (excluding dogs and cats) were used as a financial asset that could be sold, particularly to pay school fees. Thus, it was unlikely that livestock had implications for food security; rather, livestock were a result of financial assets converted to physical assets.



Figure 14: A small herd of grazing and healthy-looking cows wanders down the street with their homestead visible behind them.

4.2.5 Fishing and the fisheries value-chains in the absence of a booming Nile perch trade

Fisheries were highly commercialised, as found in Uganda (Beuving, 2010). All villages in the study area were reliant on fishing as a major income-generating activity. Some key informants estimated that 70-90% of families received direct income from fishing (however, this estimation is much greater than the 32% that was estimated by the household survey, and is discussed in Chapter 7). While many people were highly engaged in fishing activities, even non-fishers relied on fisheries-generated cash for their businesses:

More fish leads to more vegetable sales, which leads to more money for school fees.

(Male youth)

When more fish are landed, it generates cash flow throughout the community (see also Barratt & Allison, 2014). The main targeted fisheries were Nile perch (known as ‘mbuta’ in Duluo; *L. niloticus*), tilapia (known as ‘ngege’ in Duluo; *Oreochromis spp.*) and the Lake Victoria sardine (known as ‘omena’ in Duluo and ‘dagaa’ in Swahili; *Rastrineobola argentea*). By-catch fish species included catfish (known as ‘mumi’, ‘kamongo’, and ‘seu’ in Duluo; *Siluriformes spp.*) and squeaker fish (known as ‘okoko’ in Duluo; *Synodontis spp.*). The omena fishery’s by-catch included fulu (known as ‘furu’ in Swahili; *Haplochromid spp.*), the common Caridina shrimp (known as ‘ochonga’ in Duluo; *Cardinia nilotica*), and a mixture of small juvenile fish (known as ‘kanjuele’ in Duluo). While both fulu and kanjuele were consumed locally, ochonga is a low-value by-catch, used for chicken feed and not consumed by humans. Respondents did not define these smaller species (omena, fulu, kanjuele) as ‘fish’; rather, ‘fish’ referred to large fish only, including Nile perch, tilapia, squeaker fish, catfish, among others. This semantic distinguishment was important to the research in understanding key differences in the value-chain between ‘fish’ and ‘omena’. Figure 15 provides a visual charting of these fish value-chains as a starting point for a future value-chain analysis and to assist understanding throughout the subsequent text description. I have mapped and created this diagram based on data from my qualitative fieldwork (the ‘transcription’ dataset and my observations).

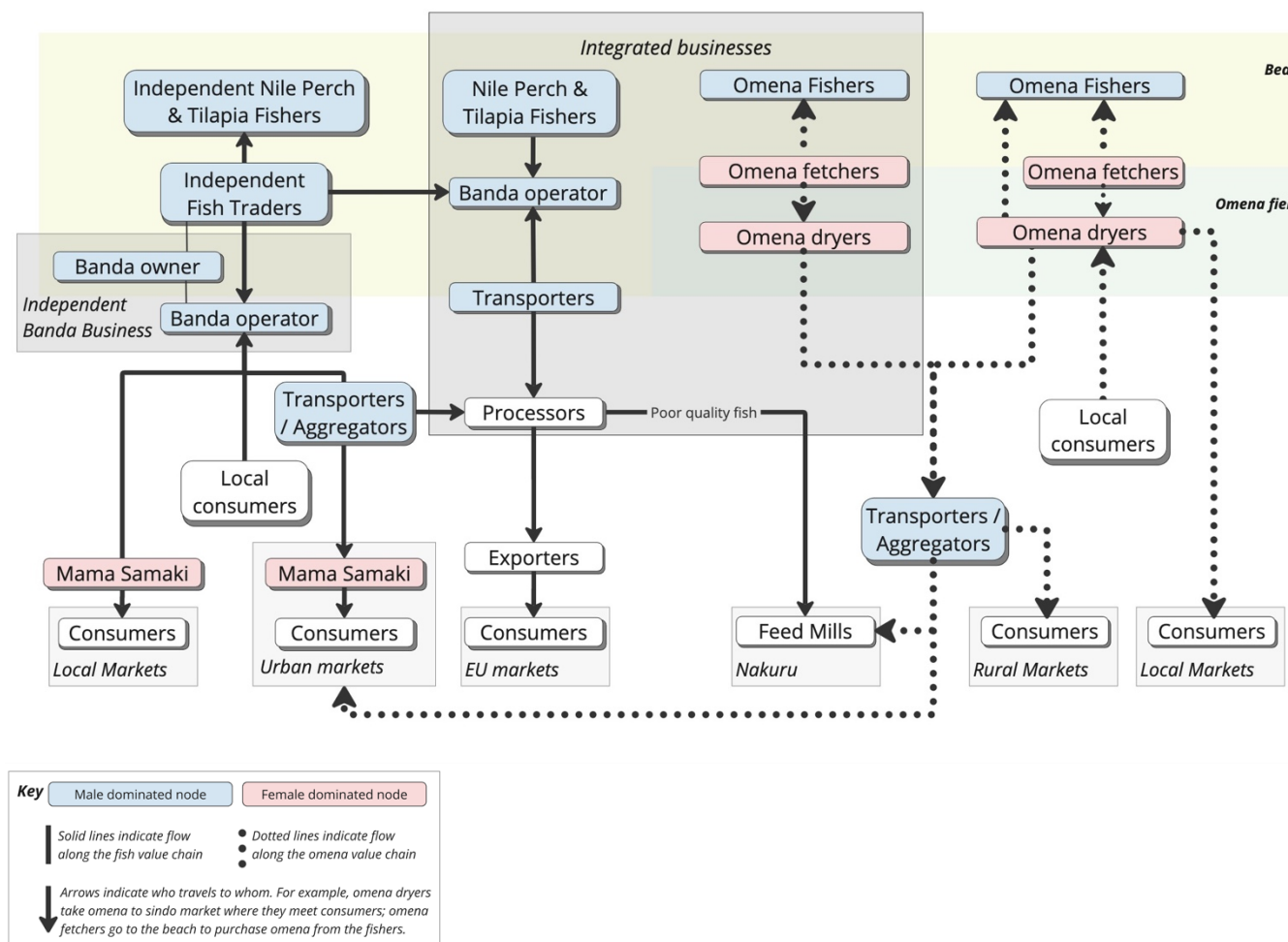


Figure 15: Description of the fish and omena value chain in Sindo, Kenya.

Commercial fishing for targeted species occurred both onshore and offshore and with a variety of strategies. Fishing was performed by both men and women; however, offshore fishing was exclusively performed by men (Figure 16). Fishing was also a male-dominated profession in rural Malawi (Ndekha et al., 2000), Ethiopia (Alemu & Azadi, 2018), Zambia (Ragsdale et al., 2022), elsewhere in Lake Victoria (Geheb et al., 2008), Lake Kariba (Muringai et al., 2020) and in South Africa's Lake Gariep (Ellender et al., 2009). A few women and children fished onshore for omena and small fish with small seine and set nets, or for larger fish with a fishing line and hook, similar to the Tanzanian part of Lake Victoria (Moreau & Garaway, 2018). Offshore fishing was conducted using hook and lines to target heavier Nile perch, whereas seine nets were used to target omena. Some women professed that some fishers use drift nets even though these are illegal. Because offshore omena fishers also used solar-powered night lights to attract omena into the nets, omena fishing was only conducted at night. The reliance on night lights also led to periodic decreased fishing activity and catch during the full moon, which caused these night lights to be less effective in drawing in omena. Some people described advantages to fishing at fish breeding grounds, such as river mouths, despite that officials clearly stated these areas are designated no-fishing zones.



Figure 16: Wadiang's beach in Sindio, framed by anchored fishing boats, omena drying fields, and corrugated iron buildings (e.g., houses, shops).

Due to differences in required equipment, some smallholder 'artisanal' boats specialised in fishing for either omena or Nile perch while other smallholder boats targeted both fisheries. Smallholders owned one or two boats. Boats were 'artisanal', i.e., small canoes operated by 4 to 6 people, navigated using oars or a small propeller engine. Due to the low cost of manpower and difficulty maintaining

larger vessels in these rural areas, artisanal fishing boats were more economical than larger vessels. Most boats were owned by men; a few women recently became smallholder boats owners, a gendered development that began in 2018. While women boat owners exclusively employed fishers to operate the boats, male boat owners sometimes worked on the boats alongside recruited males from their social networks (cousins, brothers, friends, etc) to operate the boat and fishing gear. The importance of social networks and the challenges associated with migrants in developing these social networks was described for the Ugandan part of Lake Victoria (Beuving, 2010). Unlike in Uganda, where individual operators managed to save to purchase a boat, the smallholders in the present study usually inherited the boat and equipment. These individuals were highly vulnerable: multiple respondents described experiences where their boat was burned or gear was destroyed or stolen overnight by competitors or “jealous people” (a fisher’s wife in Sindo).

The relationship between boat-owners and their crew were nuanced. While many smallholder boat owners also fished on their boats with their crew, the majority of fishers were employed and their compensation varied, dependent on the amount of catch. After the fish and/or omena was landed and sold, boat owners would negotiate with fishers to determine their cash payment for that expedition. This contrasted with Uganda, where the cash payment amount was determined before the trip (Beuving, 2010). Details on compensation negotiations between boat owners and fishers appeared complex and were not adequately demystified by the data in this thesis, and this subject warrants additional research (e.g., what were the ratios of catch retained by the boat owner versus distributed among the crew?). Regardless, it was clear from the interviews that a larger catch resulted in a higher cash compensation for both fishers and boat owners. Sometimes, fishers felt that they were not paid fairly for the catch; in this case, on their next fishing expedition, they would sell fish at other beaches prior to returning without the boat owner’s knowledge and keep the profits among themselves. Thus, potential clandestine sales incentivised boat owners to co-fish or to pay fishers fairly, although these relationships often involved conflict as was also the case in Uganda (Beuving, 2010). With the rise of large fishing businesses (i.e., vertically integrated businesses owning many artisanal fishing boats, processing stations, and trading operations originating from the height of the Nile perch boom when processing plants owned boat fleets and employed networks of traders to engage with smallholders), the prevalence of boat owners co-fishing with their crew was decreasing, as only smallholder boat owners fished with their crew. As at the height of the Nile perch trade (Chapter 3), boat fleet owners were wealthy businesspeople who invested in boat fleets but did not fish with their crew. Because these fisher crews were unsupervised on the boats, relationships between boat-owners and crew were based on trust; additionally, they were largely informal. Informal arrangements facilitated flexible compensation arrangements: when the catch was extremely small, the fish and/or omena were distributed among fishers as their pay instead of a cash payment. Fishers would then sell the fish and/or omena to traders/processors themselves. Some women mentioned that if their husbands’ boss (the boat owner) gives their husband a fish, they will eat it rather than sell it because it is a small

amount. Thus, the variable outcomes from negotiations between boat-owners and crew may have implications for food security at the household level.

Once the fishers landed, Nile perch and by-catch was sold at the landing site to (mainly male, but some female) fish traders, who took the fish to the 'bandas', which are Nile perch and tilapia trading stations. Bandas only engaged in large fish trade (i.e., not omena) and were located near the beach – distant and different from the main markets, which also include sales of processed fish, vegetables, and other goods (e.g., pots, clothes, charcoal, notebooks, etc). Normally, landed Nile perch and tilapia were negotiated for and purchased by independent traders on behalf of banda owners. Bandas usually only traded Nile perch and tilapia, and rarely traded lower-value fish, like catfish, lungfish, or squeaker fish. These lower-value fish were usually sold on the beach, purchased by people working in the fish trade for their personal consumption (e.g., an omena dryer might opportunistically purchase a small portion of catfish for their dinner that night). People working on the beach felt that Nile perch and tilapia were unaffordable due to the prices offered by banda owners. Wealthier fish consumers in the community visited the bandas rather than the beach to purchase Nile perch or tilapia. This was because trade on the beach was rapid, busy, competitive, and short-lived; bandas often had cooler boxes (though notably, not connected to electricity due to the expense nor filled with ice due to lack of a local ice supplier) and consumers could buy fish from bandas throughout the day at their convenience. Permanent banda buildings were located near the lakeshore, but with the rising water levels in Lake Victoria, many concrete bandas are now partially underwater. At the time of the study temporary shelters made of corrugated iron had been constructed farther from the water, but still on the beach. Each shelter was owned by a different banda owner and most contained a scale and container at minimum (Figure 17).



Figure 17: A banda operator holding several tilapia inside the banda shelter.

The bandas were key points for aggregating and valorising high-value fish (Nile perch and tilapias) for markets. For the large integrated businesses, their employed traders/transporters would collect fish from the business' boats at the beach and take them to the business' banda for weighing before transporting the fish regionally. In contrast, smallholder independent operators made money by negotiating prices. At the beginning of each day, smallholder banda owners estimated the price of fish on the markets based on the previous day's prices and season to calculate how much fish he wants to purchase and at what price. He provided his independent fish trader(s) with exactly enough cash to make that purchase. Fish traders went to the beach to negotiate fish prices and make purchases to deliver the quantity of fish the banda owner required with the cash he provided; the traders made money by negotiating a lower price with the fisher and keeping the surplus. When purchasing fish from boats, traders attempted to negotiate a lower price than what the banda owner expected, so that the traders could earn a commission. If the trader was unable to negotiate a lower price than the banda owner expected, they did not earn any money from the trade. Relationships between banda owners and fish traders were informal and based on trust. However, these relationships were not exclusive,

and traders may have worked for several banda owners. Banda owners communicated directly with traders, but generally did not handle fish. Instead, they hired a banda agent to receive the fish from traders and make sales to customers. This agent was an employee, paid a fixed rate per day, and was entrusted to handle all cash transactions and weighing fish for sale. Banda owners and agents were usually male, although traders were both male and female. Most Nile perch and tilapia passed through a banda and was sold/transported fresh.

At bandas, Nile perch and tilapias were sold whole by the kilo directly to consumers and Mama Samaki (women fish retailers, some of whom often deep fry the fish and sell them as convenience foods in markets). No processing occurred at the bandas: the presence of processing plants may have eliminated beach processing, as found in Uganda (Beuving, 2010), and local customers may have acclimatised to processing the fish at home such that even with the collapse of processing plants, the beach processing node may continue to be unneeded. Should consumers want a processed fish, they purchased a conveniently gutted, scaled, and fried or smoked fish from a 'Mama Samaki' (female processed fish vendor) at the main village market. Poor cold storage facilities meant that fish was purchased and consumed on the same day. Refrigeration and cold-chain facilities have a large impact on food culture globally (Marshall, 2022). Consumers also reported buying fish from markets and occasionally from fishermen, fish farms, and local restaurants or a 'Mama Samaki'. Restaurants and Mama Samaki generally sold fish fried, a preservation method extending the fish shelf-life in the absence of cold-chain facilities. This meant that fish from local restaurants was generally cheaper than from markets/fish farms.

Ideally, banda operators sold Nile perch and tilapias to aggregators, who had the purchasing power to buy in bulk for processing plants or urban markets. Larger Nile perch was destined for the specialised industrial processing plant (the one that remained opened from the Nile perch boom), which prepared the fish for international export markets. In contrast, smaller Nile perch and tilapia purchased by transporters were destined exclusively for urban markets in Kisumu and Nairobi, where vendors would sell the fish gutted and scaled or conveniently deep fried. Some Nile perch and its by-catch was retained for local markets in Sindo and the surrounding villages. Locally marketed fish in bandas that failed to be sold in the same day were sold at a discount to Mama Samakis, who deep fried or smoked the fish for resale on subsequent days. Key informants estimated that 20% of fish was retained for local (i.e., in Sindo and its surrounding villages) consumption while 80% was transported to urban or export markets (no official statistics are available and quantitative research in this area is needed).

Key informants estimated that while smallholders represented over three-quarters of boat owners in 2015, they currently represent only a quarter, replaced by large-scale integrated businesses. As summarised in Chapter 3, key informants said that these businesses appeared in the late 80s and early 90s and were characterised by a single non-local (often wealthy Indian Kenyans or Somalian

immigrants) owning a fleet of boats and trucks for aggregating and transporting fish and omena. These integrated businesses targeted all three main species (Nile perch, tilapia, and omena). For fish, these businesses employed fishers, traders, banda operators and transporters. In contrast, Beuvling (2010) described how Nile perch factory owners, traders, and boat owners in Uganda were all independent businesses, and the integration of these businesses found in the present study may be a more recent development, or specific to the Kenyan part of the lakeshore. This study found that while payment for fishers and traders was negotiated in the same way that of smallholders, their banda operators and transporters were paid a fixed salary. These large-scale integrated businesses would use their banda to weigh and package fish catch from their boats before transporting it on their trucks to processing plants in the case of larger Nile perch or to markets in the case of smaller Nile perch and tilapia. Additionally, they would engage with traders to aggregate additional fish from independent boats. While these large businesses had boats that also targeted omena, they did not employ omena dryers or any other downstream nodes of the omena value-chain. Omena could be transported wet to feed mills but were more frequently sold to local omena processors who dried the omena and sold it back to the large business for transport to regional markets (in the case of high-quality omena) or to feed mills (in the case of poor quality omena).

In contrast to the Nile perch and tilapia value-chains that used traders and bandas, omena fishers sold their catch to independent women processors ('omena dryers'). These omena dryers purchased omena from fishers by the basin instead of by weight, since boats did not have scales (Figure 18). The monthly changes to omena catch volumes affected omena market price, which was highly elastic, varying with the lunar cycle. The omena dryers brought their basins to the landed boats and the fishers filled it with omena for 1000-3000 KSh, depending on the catch abundance. The price per basin (a large plastic tub container, see figure 18) was highly variable, ranging from 1000 KSh for a full basin during the new moon and 3000 KSh for a full basin (2000 KSh for a half basin) during the full moon. The price per kg was highly variable, because (1) fishers would pile omena and fill basins more generously during periods of higher catch, and (2) the size of basin varied. Omena dryers strategized by acquiring slightly larger basins and/or treating new basins by pouring hot oil in it, to warp the bottom of the basin downwards and increase the volume of omena it could contain. Omena dryers would go to the boats directly or employ 'fetchers' to purchase and carry the omena from the beach to the drying areas. While children did not participate in the formal fish or omena value-chain, some children collected leftover omena and small fish from boats and beaches, selling them for cash to purchase candy or baked goods.



Figure 18: Women carrying and buying omena on Wadiang'a beach during the new moon, when omena was plentiful.

Once fresh omena was purchased, the omena dryers placed nets on the ground, upon which omena was spread thinly to dry in the sun for one to three days for preservation purposes (Figure 19). Nets were secured in place with large rocks. The dryers either used smaller areas around their houses to dry the omena or paid for rented space in 'omena fields' to secure a free space. This land was owned by wealthier members of the community and the rental price varied, depending on individual negotiations between the land owner and the omena dryer. Omena dryers described the relationship as exploitative (although none of the landowners were interviewed as part of this research and their perspective remains to be captured). Omena dryers sat by their product while it dried, often clustering with other dryers under a nearby tree, throwing small stones and pebbles to keep birds and other predators away with only temporary success. Omena dryers were almost exclusively female (only one male omena dryer was observed on one day), and their children and infants are often nearby. Omena watching and childcare were relaxed activities, and an informal cooperative approach was observed, where women would tend to other women's' omena and/or children if they needed to leave the area briefly. Key informants were unaware of any social groups, cooperatives, or BMU representation for omena dryers. Once the omena dryers collected their product, older women (often

marginalised and desperate for cash) would search the omena drying fields to collect any leftover omena and sell it for cash as a gleaning strategy.



Figure 19: Omena dryers rent space in this field to dry omena on their nets on the ground, securing them with large rocks.

Omena dryers had two main strategies for selling the dried product. If the omena dryers had enough product, they sold it to independent aggregators. Aggregators estimated the weight of the omena using a standardised ‘tin’, equal to approximately 2kg. Prices were negotiated daily with the changing availability of omena and the estimated quantities of omena delivered. Once a sufficient bulk of omena had been purchased, aggregators transported the dried omena to rural and urban distance markets or to animal and livestock feed mills located mainly in Nakuru. Aggregators either owned their own trucks or used public transportation to transport the product. Omena dryers and aggregators-transporter-traders were different actors, and no overlap was observed in the study area. Omena dryers were processors only. Traders aggregated, conducted trading between omena dryers and feed mills without value-adding the product, and transported the product to the feed mills.

If omena dryers had smaller quantities (for instance, during the full moon), undesirable by aggregator-traders, they would transport the omena to market themselves on foot or by ‘bodaboda’ (motorcycle taxis); however, omena dryers’ preferred sales avenue was to the aggregator because it required less labour and risk for the omena dryer. Regardless of the lunar cycle, aggregators would

buy up large quantities and immediately transport the omena to feed mills (i.e., not storing it). Aggregators seemed to be more in control of the value-chain and able to set prices, compared to omena dryers who scrape profit margins. A full value-chain analysis was not conducted but is warranted, both at the local and Lake Victoria regional scale, to understand volumes, profit margins, and degree of risk associated at each value-chain node.

Consumers mainly sourced omena (and fish) from markets (Figure 20); occasionally, a consumer had a favourite omena supplier and bought omena directly from her at her field. Regardless of the point of sale, omena were sold by the tin, as used by the aggregators. The market sales price for a tin was highly elastic, ranging from 350 KSh per tin during the full moon and 100 KSh per tin during the new moon (as of October 2023). Thus, omena dryers must sell over ten tins to turn a profit, regardless of the moon. The omena drying trade is risky because profit potential varies significantly: omena dryers estimated that an average basin of wet omena equates to eight to ten tins of dried omena. The low profitability of omena trading was also described in Uganda (Beuving, 2019). In contrast to fish, omena is mainly sold in dried format and very few key informants reported eating fresh omena. Because profitability is contingent on high sales volumes and local sales require more time, omena dryers preferred selling to an aggregator.



Figure 20: Women fish vendors wait for customers on raised platforms, with their dried fish in front of them. The large basket in the centre of the photo contains ‘kanjuele’, a mixture of omena, fulu, and juvenile fish.

4.2.7 Economic stratification: “We are poor – we have no choice.”

Economic stratification was important to respondents when describing social hierarchies relevant to food security within Sindo; therefore, my methods were designed to collect data that characterised and quantified differences between better and worse-off people (as described in the methods sections: Chapter 6.1.2 on the ‘physical wealth index’).

Key informants revealed differences in economic classes: The main differences between the rich and poor were about food choices and social status. As one female omena-dryer commented, “Whatever the rich man want to eat, they can afford and buy – I have no option.” Generally, most key informants agreed that rich people could afford a balanced diet and were satisfied with their diets, whereas the poor had limited choices, eating only what they could afford. Key characterisations of a rich person’s diet included a balanced diet, a variety of foods, three meals per day, the ability to purchase food

from a supermarket, milky tea, beef, farmed fish, bread, mandazi (a fried sweet bread, often made with cardamom), chapati (a flatbread), soda, and fruit. The concept of a balanced diet likely came from a dietary education intervention that aimed to improve local dietary diversity through behaviour change (Korira & Tuitoek, 2023). In contrast, the poor ate less variety, relying on maize porridge, omena, vegetables and ugali. Anger was largely absent; rather, I observed despondent acceptance. One omena dryer said lightly, “I take my porridge and life goes on.” In addition to differences in food choices, wealthier economic classes occupied a higher social status than poorer ones. Key informants described that the rich were respected, whereas the poor did not have respect. Key informants explained that richer people were supported by an inheritance, whereas poorer people had to “struggle on their own”.

A lack of consensus existed around the continuity of the Luo culture of food sharing. Sharing of food appeared common, particularly within kinship networks, and seemed to be an important value in the community. A woman from Sindo responded to questions about how food was served by saying, “You eat, knowing that others have not been served.” People were conscious that whatever food was available should be distributed so that everyone at the table can eat, even if it meant no one was full. Owino (2019) also discovered that eating was a household communal activity, where people share what is available. Ogoye-Ndegwa & Aagaard-Hansen (2006) suggest that sharing food is important to Luo culture, even during famines. Even the reverse food remittances – where households sent food grown on their homestead to family members working in other areas – were an expression of subsistence obligation among kin (Djurfeldt & Wambugu, 2011). Local feasts and ceremonies, like for funerals or weddings, can be important food reallocation for disadvantaged people in the community (Riang’a et al., 2017). In many cultures, food goes beyond physical nourishment: food can have emotional value and its consumption can define relationships and cultural identity (Okoror et al., 2008). Consuming food together can be a symbolic gesture of familial unity creating feelings of love and caring; exclusion from food preparation and sharing can cause negative feelings of rejection, shaming, and pain, such as with women living with HIV/AIDS whose families prohibit them from cooking due to fears of disease transmission (Okoror et al., 2008).

Yet, a lack of consensus existed about whether traditional norms around food sharing were persisting or had largely disappeared, related to migration into the area. Systemic flux in attitudes to food may be manifesting. On several occasions, people commented on the poor borrowing from the rich, but lamented that even the richer households were worse off compared to twenty or thirty years ago. One woman commented, “even the rich lack to assist you”. This points towards overall worsening of the community’s food security over time. In contrast to our key informants’ perspective, other authors have argued that the importance of kinship in migratory fishing communities persisted, despite that migration trends seemed to have largely decreased (Beuving, 2010; Sileo et al., 2016). Migratory influx, followed the economic implications of the Nile perch industry collapse and a lack of outward migration may have contributed to worsening food security. The literature described a mass influx

of migrants during the Nile perch boom and a failure to return home. The original migrants have stayed and built families around the lake. Our key informants note that people still migrate into Sindo, but the rates seem to be much lower than during the Nile perch boom. Yet, key informants also estimate that over 95% of local population were of Luo ethnicity, which suggests that migrants into Sindo must have also been Luo, which reside primarily around the lakeshore. The mass migration may not have been a mass migration from across Kenya but rather from surrounding mountainous areas to the lake shore. This warrants further investigation.

Capital differences between the rich versus poor were also seen in: the structure of the house (permanent bricks versus corrugated iron sheet walls, mud versus tiled floors, Figure 22); the children's schooling type (private or boarding versus public or day schools); whether the women could afford weaves or regular hair dressing services; ownership of a refrigerator, car, boats, or a lorry (in contrast, everyone owned a tv and a cell phone); the fabric of people's clothing (traditional African prints or suits versus second-hand American or European clothing); cattle ownership (many versus no cattle) and employment (a fish farm job or fishing boat business versus participation in the omena drying business). Although a person's wealth was previously judged not on their clothing but by their physical body (fatness indicates quality feeding, whereas thinness is associated with disease, HIV, and lack of food; Ogoye-Ndegwa & Aagaard-Hansen, 2006), the present study found that women also judged a person's wealth based on the fabric of their clothing, where cotton t-shirts and westernised clothes sold through the second-hand market are cheaper and more accessible than traditional fabrics. Additionally, selling locally-grown vegetables and participation in the omena drying business were associated as a poor woman's activity. One focus group with a women-only table banking group noted differences in the way rich and poor people speak: "Rich people are polite, but poor people respond with heat". Another group of omena dryers mentioned that the "way of talking" differed between the rich and poor, because the poor lacked time for words. These differences between the better and worse off were key for the quantitative work, as discussed in the following chapters.



Figure 21: Visual differences in better versus worse off housing structures.

The types of food a person ate depended on how much cash they had, and poorer people relied on foods that were cheaper. The older participants in the present study described a transition from a subsistence to a money-oriented economy, particularly regarding fish and maize. This transition was also described by Ohiokpehai et al., (2007) and in the urban Kenyan cities Naivasha (Volpato & Ellena, 2023) and Mombasa (Smart, 2017). Most food was purchased and little subsistence farming existed, as also found by Ohiokpehai et al., (2007). For instance, livestock was a form of savings rather than a subsistence crop, and people bought beef from a butchery. If banks and financial rates

of return are unavailable from a lack of financial institutions, livestock and feeding them for growth are a form of capital accrual, offering cash withdrawal upon sales. While many people grew maize, most consumed maize was purchased because home-grown maize could not be milled at home and was instead sold to millers. In addition to foods that needed processing, imported foods were also more expensive. For example, chapati (made from wheat flour), green grams, and milk were considered expensive; indigenous leafy green vegetables and locally-produced omena and ugali were affordable (see also Smart, 2017). While fish (other than omena) was also locally produced, its cost reflected its high export value from the lake vicinity to other areas in the region, limiting local accessibility.

Food commoditisation had complex links to food security, depending on whether it supports or deters diverse diets. Due to food commoditisation, income from off-farm employment and on-farm sales was more important for households' food security than subsistence farming activities in Uganda (Wichern et al., 2017). For the wealthy, food commoditisation and increased international and regional trade can lead to more diverse diets. Khoury et al., (2014) reported that while agrobiodiversity is trending toward homogeneity at the global level, increase in international trade has resulted in a higher diversity of foods at national levels, pointing towards the importance of international trade for diverse diets. In contrast, food commoditisation may have negative consequences for the poor who lack cash for food purchasing. For instance in Malawi, livestock reared for income rather than consumption has been linked to low ASF intake (Chingala et al., 2017). Johns et al., (2004) argued that increased agrobiodiversity resources in local food systems though small-scale production can support food security for the undernourished poor.

Because food security relied on cash in the study area, the poverty level in the study area was a concern expressed in all conversations as the main barrier to food security. Key informants used descriptive terms like:

A dead economy. (Fish farmer)

No vibrant microeconomy. (Politician)

People cannot afford food. (Female elder from a littoral village)

The local economy was highly dependent on cash inflow driven by the fishing industry; thus, the declining catch-per-unit effort of Lake Victoria's fisheries and the growing population have negatively affected the local economy. Key informants made comments including:

Everyone relies on fishing for income. (Fisheries governance representative)

If fishing does well, we all do well. (Politician)

When we stop fishing, there is nothing to eat. (Fisher from Sindo)

Decreased fisheries productivity resulted in less income for people engaged in the value-chain and thus lower purchasing power for auxiliary services and commodities – including food purchasing. This led to reduced economy activity generally and worse food security. Many omena dryers complained that they lacked money for three meals, subsisting on porridge for breakfast or lunch and “holding out” for ugali and omena for dinner. Poorer key informants complained of hunger, and these people were concerned with having enough food generally. Worse-off key informants – both those living farther from and closer to the lake – had a greater prevalence of hunger than better-off key informants. Indeed, most key informants stated that hunger was problematic in their communities. Problems and concerns arising from food commoditisation are seen elsewhere (Longhurst, 1988; Whyte & Kyaddondo, 2006; Rubhara et al., 2020)

Across the study area, poverty was characterised by a lack of food choices. Key informant said:

I'm eating, but in a hard way... I survive with porridge and wait for ugali at night.
(Young omena-drying woman in Wadiang'a)

We eat what is available. (Middle-aged worse-off female member of the table banking group)

We have to eat whatever we can afford for that day. (Female table-banking member)

Worse-off people relied on either ugali and omena or ugali and indigenous leafy green vegetables as affordable foods (Figure 23). Worse-off people near the lakeshore relied on omena. The omena drying women complained that they ate omena every day and wished they had a wider variety of foods in their diet:

We must eat omena. (Middle-aged omena-drying woman in Sindo)

I only eat omena and ugali. (Young omena-drying woman in Wadiang'a)

A day can't end without me eating omena! (Older woman in a worse-off fishing village)

According to the poor, the only notable benefit to omena over other fish species was that it was consumed whole and picking out the bones was unnecessary. In contrast to the omena dryers, women and men farther from the lake relied on leafy green vegetables and expressed a desire to eat more omena. This demographic was in areas with more agriculture and access to forageable forests; thus, their staple meal was ugali with locally-grown and indigenous leafy green vegetables. Gastrointestinal illnesses, like heartburn, or allergies were commonly cited by key informants as reasons for not eating particular foods. Frailty associated with age further decreased choices around food. Older people unable to chew the food available in the evenings were given leftover porridge.



Figure 22: My translator Sally prepares dinner for us (wet fry omena and apoth) before we sit together to transcribe interviews.

In addition to limited cash for purchasing and health concerns, several food taboos further restricted options for food, increasing the relative importance of fish as food, as found in Tanzania (Moreau & Garaway, 2018). Household food availability and even affordability may not equate to accessibility and consumption due to taboos and socio-religious restrictions (Musyoka et al., 2023). For instance, both ochonga (a small freshwater shrimp species) was abundant and caught as a by-product of the omena fishery; while ochonga is widely consumed elsewhere in Sub-Saharan Africa (for example, Nigeria and Ghana), people in the study area perceived it as chicken feed rather than fit for human consumption. Similarly, despite that reptiles like monitor lizards were also abundant and safe for consumption, reptiles were taboo foods. In addition, many locals refrained from eating in public due to a fear of contracting ‘girchuny’, a form of juok (witchcraft). ‘Girchuny’ is a bad energy that passed from an infected person through their eyes to another person who is eating. Ogoye-Ndegwa & Aagaard-Hansen (2003) also described many superstitions regarding food in Luo culture. Unlike in previous studies, male respondents did not suggest that eating apoth was bad luck for fishers (Ogoye-Ndegwa & Aagaard-Hansen, 2003). This suggests that superstitions around particular foods may be waning, or that, faced with a lack of choice, people are prioritising full bellies regardless of the superstitious risk. Younger generations in western Kenya are also becoming more open-minded to novel foods, consuming based on availability and preference rather than prohibitions or taboos (Musyoka et al., 2023).

Kenyan Luos have several food taboos. For instance, the present study found that infants are not given eggs because it makes their tongues ‘heavy’ and delays speech development, as also found by Musyoka et al., (2023). Eggs are traditionally taboo in Luo culture and their consumption is triggered by famine (Ogoye-Ndegwa & Aagaard-Hansen, 2006). Pregnant and breastfeeding women avoid eggs and prioritise consumption of fish for healthy babies (Musyoka et al., 2023). Taboos about various foods’ influence on pregnancy and childbirth are common (Riang’a et al., 2017; Musyoka et al., 2023). Musyoka et al., (2023) identified several other taboos among Luos have been identified that were not mentioned in the present study, including: (1) that chicken has medicinal cleansing properties and can ‘chase evil spirits’; (2) that women, girls, and children are prohibited to eat poultry, eggs, and omena for various reasons (Musyoka et al., 2023); and (3) except for older women, Luo women should not eat mutton or lamb (Owino, 2019).

In contrast to poorer people, better-off people could afford more food choices. Wealthier people felt that they had flexibility to accommodate their cravings and “eat whatever they want” (Omena drying woman in an impoverished littoral village). Wealthier key informants described making their own food schedule based on their own food preferences or their husbands’. While key informants unanimously agreed that only women were responsible for cooking, some said that men were responsible for choosing the menu whereas others commented that it was a joint effort. Men provisioning women with money for food and a ‘food schedule’ was also found by Bukachi et al., (2022). Wealthier key informants acknowledged their choice:

If I feel like eating chicken, let me slaughter it. (A wealthier woman from an inland agricultural village)

I came from a bit wealthy family and ate whatever I wanted. (A worse-off woman in an agricultural village, reflecting on her wealthier childhood)

Better-off households also felt they lacked choices due to an inconsistency of supply – for example, fish (other than omena) was not always available when fishers’ catch was poor. In addition, wealth was associated with health, since cash was imperative for purchasing nutritious diets and healthcare.

Better-off people were concerned with having a ‘balanced diet’ rather than simply having a full belly. People with access to money could afford to choose a “timetable” or “food schedule”. These were perceived as an important component of food security because they enabled a ‘balanced diet’. Respondents frequently demonstrated an awareness of needing a ‘balanced diet’, generally defined by:

Different foods make a balanced diet. (Female farmer)

A diet with different foods that give you energy, like ugali, or give you vitamins, like mangos. (Male youth)

One focus group agreed that nutritional density creates a “bitter” taste. This concept of ‘a balanced diet’ was generally taught intergenerationally and in education curriculums. Owino (2019) also commented on the desire for a ‘balanced diet’ among Kenyan littoral residents.

The inability to choose a food schedule and a lack of food choices increased subjective food insecurity. Worse-off people balked or laughed when asked “what is your favourite meal?” because they felt their food preferences were irrelevant in their life that had little choices. Likewise, worse-off mothers did not know their children’s favourite foods. Regarding her family, one woman remarked, “Whatever is served, they will eat.” Indeed, one omena dryer said, “I don’t have money for our hearts’ desires”. Furthermore, poorer people felt that their lack of food affected their food culture. The only traditions identified were prayer prior to eating and having a large meal with many dishes at Christmas. As one worse-off woman from Sindo explained, “I don’t have traditions – I eat what I can afford”.

Because omena was a locally produced and highly affordable food, omena consumption was associated with poverty. A key aspect to the affordability of omena was its portionability as a small fish – regardless of how much money a consumer had, they would be able to get a portion of omena. In contrast to omena served by the spoonful, Nile perch and tilapia were sold whole and portioned among people within the household (notably, catfish and lungfish were portioned for sale, where women sellers cut pieces in different sizes according to how much money their buyer had to spend). The association between poverty and omena was prevalent throughout the key informant discussions, as most conversations contained some variation on “omena is food for the poor”. Its association with poverty was strong and its consumption carried a burden of shame (see also Allegretti, 2019)s:

If you had guests coming to your home, you don’t cook omena. That’s an insult, literally... You cook tilapia. You serve your guests well. (Politician)

Tilapia and Nile perch were associated with a higher status than, and thus preferred over omena. Generally, beef and fish (other than omena) were the preferred animal source food; however, as one government official said, “Everyone will eat fish, but only some can buy it.” In conversations with fishers and power-holders (e.g., BMU representatives, fisheries officers, elders), Nile perch and tilapias were perceived as more important than omena, despite worse-off people’s dependence on it. Omena was generally an afterthought and not prioritised among power-holders despite being a critical livelihood-generating activity for so many fishers and women processors.

Yet, omena is increasingly recognised as a highly nutritious food and its low-value status may be changing:

People [are beginning to] realise the nutritional value of omena. So you find the urban middle class now actively looking for nice clean omena. (Politician)

The politician also believed that the urban poor have an increased demand for omena because they observe the middle class consuming it as a nutritious food item. While omena was well accepted as a nutritious food, omena drying women noted that “it’s more valuable to sell omena” than to retain it for household consumption. For these women, their food ennui related to an over-reliance on omena paired with a lack of cash for purchasing a more diverse diet drives the perceived importance of omena as a ‘cash crop’ rather than a nutritious food.

This section explains that the study area was in a transition from a traditional to a modernized and commercial food landscape and cash was increasingly important for food security. Thus, wealth enabled better food security, as greater purchasing power enabled food choices and dietary diversity. Wealthier people had more choices due to their higher purchasing power that gave them access to a wider range of foods that included imported products. As food accessibility was mainly driven by its affordability, poorer people had less choices and relied on locally available products, mainly maize, omena, and indigenous leafy green vegetables. While omena consumption was ubiquitous, its consumption was associated with poverty. Meanwhile, the consumption of other fish species and other ASF was associated with a higher social status. However, the social status of omena consumption may be changing as it is increasingly recognised as a nutritious food item.

4.3 Rationale for the study site

This study area was selected primarily for opportunistic reasons: I was offered a project manager position for a feed trial at Victory Farms, which funded my travel and subsistence costs and allowed me to collect data for my own PhD in my spare time. While perhaps not proactively chosen, this study area was fortuitous for several reasons. To begin to understand the role of fish in food security in Sub-Saharan Africa, situating the research on Lake Victoria – as the largest freshwater lake on the continent with a significant littoral population reliant on fisheries – was ideal for my research aims. As a large region, situating the research in Sindo may provide insights or inspire additional research into other littoral communities around the lake. Furthermore, it is warranted to study food security in a region that has high poverty rates in a continent with documented and prevalent food insecurity issues (Chapter 2). Sindo is a village in transition, where the vacancy created by the Nile perch industry collapse is beginning to be filled by an aquaculture industry. The impact of this transition on the Lake’s residents is critical to understand so that negative consequences on these communities can be avoided and opportunities for any benefits to be realised. While the findings from this site may not be currently representative of most of Lake Victoria’s littoral communities not yet exposed to large-scale aquaculture, this site may represent the future of littoral life around Lake Victoria: Sindo is positioned immediately next to the largest fish farm in Sub-Saharan Africa, and other villages around the lake may face similar experiences to Sindo as the aquaculture industry develops, an inevitable consequence of regional ‘Blue Economy’ growth political strategies.

Chapter 5: Methodological approaches

This section aims to provide a discursive overview of the methodological approaches used. The methodology was mainly exploratory. The factual methods are described in depth in each chapter. In this section, I first argue the need for a mixed method approach to understanding the role of fish in food security in this study area, which underpins the novel and unique contribution of this thesis to the wider literature. Then, the methods are broadly described for both the qualitative and quantitative approaches, after which summary of the obtained datasets is presented. This section concludes with discourse regarding ethical considerations, positionality and reflexivity.

5.1 The need for mixed method approaches

This thesis employed mixed method approaches to understand the role of fish in the food security of the littoral Kenyan communities of Lake Victoria. It resulted in six main methods: (1) interviews and focus groups; (2) an Oral History activity; (3) a Photovoice activity; (4) a structured household survey; (5) an intrahousehold survey; and (6) food intake measurements. The first three were qualitative and the latter three were quantitative.

The benefits to mixed methods approaches are widely recognised (Bryon, 2016; McKim, 2017; Tashakkori & Teddlie, 2021). The main advantages include the ability to triangulate, to validate findings, to explain the qualitative and quantitative results, to off-set the weaknesses of each methodology, and to achieve a more complete understanding. In addition to its broader benefits, mixed method approaches are important for food security research in several ways (Lepiller et al., 2024). For instance, ethnographic research and qualitative work around semantics is needed to understand local food syntax and accurately interpret quantitative data (Johnson, 2017). For instance on islands in Uganda, maize-based ugali only become considered as ‘food’ when paired with a sauce or chutney commonly used to accompany ugali (Whyte & Kyaddondo, 2006; Johnson, 2017). Thus, fishers who honestly report having problems sourcing ‘food’ may be referencing maize or grains for ugali and not the fish for sauce (Johnson, 2017). Thus, researchers were led to believe all food including fish is scarce, while the reality may be that crops are scarce while fish for sauce is abundant (Johnson, 2017).

When researchers visit [Ugandan] islands like these, and ask whether residents have difficulties sourcing food, fishworkers honestly report that yes, food is a problem. Because most Europeans and Americans and European- and American-trained researchers do not recognize differences between food and sauce... Sauce rarely, if ever, enters into the conversation. (Johnson, 2017: p 10)

Thus, this qualitative work to understand the language of food was critical to accurately measure diets in the subsequent quantitative studies. Additionally, quantitative approaches that only measure

the nutritional contribution of fish can lead to unsubstantiated claims about its potential role as a food. Fish consumption advisories should be in line with communities' fish consumption habits and food culture (Andrew et al., 2016; Cox et al., 2017; Riang'a et al., 2017). A consideration of the role of a particular food within cultural and preferential boundaries is relevant to conclusions and policy recommendations to ensure their success. Furthermore, wellbeing is informed by both biophysical contributions of diets as well as subjective experiences of food (Maxwell, 1996; Serra-Mallola & Lebrund, 2023). A person's satisfaction level with food can impact on their wellbeing. Overconsumption of one particular food can cause dissatisfaction and unease, regardless of its micronutrient contribution to that person's diet. Qualitative data provides people's subjective experiences and feelings about food security whereas quantitative data identifies potential nutrient deficiencies within the diet and physical and/or financial limitations to achieving food security. Using both enhances the credibility of the research and better informs future developments or interventions that sustainably support local food security. For these reasons, an interactionist approach was used, considering that the role of fish in food security is a result of biological and physical systems interacting with social and cultural drivers (Angrosino, 2007).

Indeed, mixed method approaches have been used to study Lake Victoria's fisheries (e.g., Whitworth et al., 2019) and food security (e.g., Harris-Fry, 2020); however, to the best of our knowledge, mixed methods have never been used to study the food security of Lake Victoria's littoral populations. Thus, this thesis used the mixed methods framework developed by Cochrane (2017) and I will describe this method now. This framework includes the following methodological steps:

- (1) contextualisation (i.e., of the area, as presented in the previous chapter);
- (2) community perception and survey development (i.e., data from the observations, interviews, and focus groups were used to inform the survey design);
- (3) household survey (i.e., the household survey);
- (4) verification (i.e., verifying and corroborating findings of the household survey through other methodological approaches including the intra-household survey and the dinner intake study);
- (5) replication (i.e., replicating the methods across several villages/populations in the study area); and
- (6) engagement (i.e., presenting results to stakeholders will be done post-thesis).

As advised in 'contextualisation' (1) and 'community perception and survey development' (2), informants were consulted to develop a household survey (3). While Cochrane (2017) only used interviews for the purposes of household survey development, this thesis recognised their powerful

contribution to understanding subjective experiences of food security and coded these interviews for a robust qualitative interpretivist analysis (this analysis will be described in detail later). Verification (4) was employed in several ways. Firstly, the household survey was verified for accuracy and comprehension, and tested with four key informants (my translators, a female elder, and a male government representative) prior to data collection. Secondly, the two datasets were used for triangulation: while the qualitative interview dataset informed the household survey design, themes identified from the analysis of the qualitative interview dataset were validated using quantitative surveys. For instance, Likert-scale questions were used to quantify the broader population's degree of agreement with statements and opinions provided by key informants. Similarly, intrahousehold dietary data was collected to verify informant claims of gendered dietary quality. Indeed, the methods for the overall thesis were iterative, in that qualitative methods informed the development of subsequent quantitative methods in addition to the analysis and interpretation of the results (Figure 24). Unfortunately, resource limitations prevented a follow-up survey, where the results could have been presented back to the community to generate a further round of follow-up interviews. This additional step would be ideal for additional verification of the results and their interpretation. Replication (5) of the survey and interviews was conducted in sites across the study area. The final step, engagement (6) remains pending. Upon the completion of this thesis, I aim to achieve the final step (6) engagement, defined as,

Working within and beyond communities to engage stakeholders to ensure the ideas, priorities and findings that emerged from the research are used to support better informed decision making. (Cochrane, 2017)

I will do this by: publishing the findings in academic journals; distributing key findings to participants in the format of infographics on posters; and delivering memos of the key findings to aquaculture, governance, and development contacts who are working towards improving the food security in the area.

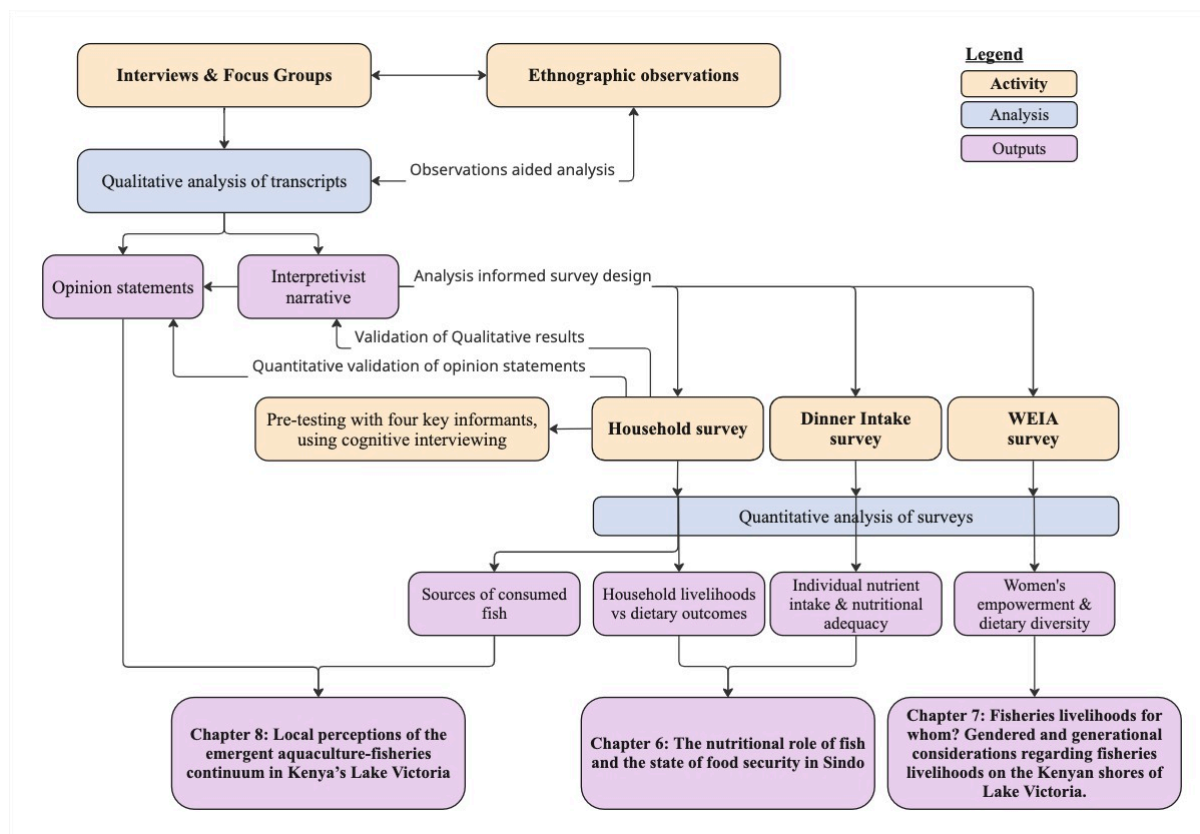


Figure 23: Schema of interlinkages and interdependencies of the thesis methodologies.

5.2 Qualitative approaches

Qualitative methods were employed during the first stage of research in the study area. These included ethnographical observations and semi-structured interviews and focus groups. These methods aimed to understand the local food and fish systems and uncover the opinions, perspectives, and experiences of residents in the study area. While this research can in no way claim to be ethnography, several of its methodologies were ethnographically informed, using an inductive approach (Angrosino, 2007; O'Reilly, 2012). Some of the results of these methods are presented in Chapter 3, providing a description of the study area and its population. The thematic results regarding the participants' perceptions and experiences are integrated throughout chapters 6, 7, and 8, conforming to mixed methods research style.

Ethnographical observations were critical in supporting qualitative exploration of the study area and informing the analysis presented in all four discussion chapters. During my fieldwork, I lived at the commercial tilapia farm (Victory Farms) running several feed and performance trials. I lived there for an initial period of six months, followed by a second period of three months, and two follow up one-month visits. Any time not spent on these trials was spent in the surrounding communities conducting fieldwork specific to this thesis. I engaged as a 'non-participating observer with interactions', which means that I did not participate in the activities I was observing but I interacted with those participating in the activities (Bryman, 2016; Balcom et al., 2021). Observational data

(activities, actions, emotions, conversations; Balcom et al., 2021) were collected around the villages, beaches, markets, and other public spaces. Photos were used to as a memory aid (Bryman, 2004), supplementary to my field notes. Additionally, ethnographical observations involved informal conversations with people curious about my research and with my research team (two translators/enumerators and one data entry specialist). This data was recorded in my field notebook as conversations occurred or shortly thereafter (Schensul & LeCompte, 2012). Although my activities were conducted in a public space, meetings with local leaders (elders and local government representatives) were arranged prior to data collection to inform them of my activities and, while not legally required, request their approval to conduct my research in these spaces. Snowballing methods were used to identify other leaders that might also need to be consulted.

5.3 Quantitative approaches

Following the qualitative work, two quantitative studies were used to further investigate the role of fish in food security – mainly, to understand nutrient intake and livelihoods generated from aquaculture and fisheries. The quantitative methodologies were a household questionnaire and measuring dietary intake at dinner as the main meal. Nutrient intake was estimated by measures of nutrient intake for the main (evening) meal complemented by recall of the previous 24 hour intake obtained from the household questionnaire.

Each chapter will describe the aims, survey tool design, data collection (including sampling and inclusion criteria), and statistical analysis. Each chapter also mentions when information and consent was recorded; however, details on consent and ethics can be found in further down in section 5.6.

5.4 Summary of the obtained datasets

In summary, the methods detailed above resulted in the following four datasets (Table 6). Results from the ‘transcriptions’ dataset are separated into two: descriptive results were used to contextualise the study area in chapter 4 and the results of the inductivist analysis were integrated with the three main discussion chapters. Chapter 6. “The nutritional role of fish and state of food security among Kenyan communities on Lake Victoria’s shores in Sindo” included all the dietary data analysis and evaluates the relationship between fish, wealth and livelihoods from the ‘household’ and ‘dinner’ datasets. Chapter 7: “Fisheries livelihoods for whom? Gendered and generational considerations regarding fisheries livelihoods on the Kenyan shores of Lake Victoria”, used the inductivist analysis from the ‘transcriptions’ dataset and ‘Women’s autonomy’ survey results. Chapter 8: “Local perceptions of the emergent aquaculture-fisheries continuum in Kenya’s Lake Victoria” also used the inductivist analysis from the ‘transcriptions’ dataset and the Likert-scale questions from the ‘household’ dataset.

Table 6: Summary of the four datasets procured and collected in this thesis.[illegible]

5.5 Ethical considerations

Ethical considerations were prioritised throughout the methodological design, execution, and analysis. As the research was situated in both the UK and Kenyan context, ethical standards had to comply with each country's expectations (Zhang, 2017). This avoided 'ethics dumping', a practice where North Americans or Europeans sidestep local research restrictions by conducting research in LMICs (Bryman, 2016). Furthermore, principles of fairness, respect, care, and honesty guided methodological design and fieldwork (TRUST, 2018). Examples of this include: ensuring that the research was relevant to the study area, providing information in ways that were accessible by all participants regardless of language or literacy barriers, identifying mechanisms for returning the results of the research to the participants, and collaborating closely with local translators who were fairly compensated. Deception was entirely avoided, and my relationship with the local fish farm was explained upfront using overt strategies. At least one month prior to fieldwork, all methodological designs were approved by the General University Ethics Panel at the University of Stirling. A PhD research license was obtained from Kenya's National Commission for Science, Technology, and Innovation (NASCOTI) in collaboration with the Kenya Methodist University (as recommended by Bryman, 2016). The design was informed by participatory methods (Minkler & Wallerstein, 2003): although the research aims were pre-determined by the researcher and not the participants, I aimed to create space that encouraged participants to share the information and experiences they felt were relevant to understanding the role of fish in their food security. The PhotoVoice and Oral History activities involved a greater degree of project aim co-creation, where participants decided on the outputs of the activities.

During fieldwork, attention to ensure the wellbeing of the participants was prioritised. For instance, elders were explicitly assured that they could suspend the interview if they were tired, and all discussions accommodated the work schedules and commitments of the participants (Zhang, 2017). For this reason, participants sometimes drifted in and out of focus groups to, for example, tend to their omena. Furthermore, practical steps were taken to document consent. Prior to all research activities (except for observational and informal discussions), the interviewer reviewed the information sheet and consent form with the participants (Appendix 6). Consent forms were signed at the end of the interview so that participants could approve the use of information shared during the discussion. No identifying data was collected to protect the participants' anonymity. As it was impractical and impossible to obtain recorded consent for observational work and informal discussions, these activities were always conducted in public spaces where I was placed in plain view.

Several additional steps were taken so that ethical practices extended beyond the prescriptive instructions and recommendations set out by national and university requirements. Primarily, a field diary was maintained alongside field notes throughout the fieldwork. While the field notes attempted

to objectively document observations, activities, key quotes, etc., the field diary included descriptions of my own subjective reactions to emotive experiences and documented my authentic response to my fieldwork (Hume & Mulcock, 2004; Punch, 2012). Post-fieldwork, the diary supported a reflexive activity (Chapter 4.7), which was critical to assess the moral dimensions of and the effect of my positionality on the research (Hume & Mulcock, 2004; Punch, 2012).

5.6 Positionality, Reflexivity, and Field Diary Analysis

The nature of my positionality within the community, particularly as an American-European in rural Kenya, must be acknowledged because it created biases that are inevitable and ingrained (Punch, 1998; Brasher, 2020; Rüller et al., 2020). A reflective approach on my positionality is appropriate to acknowledge and consider the role of these biases in the project outcomes (Brasher, 2020; Rüller et al., 2020). Many researchers do not admit to the inevitably awkward situations that arise from fieldwork that have both emotional and physical reactions (Hume & Mulcock, 2004; Punch, 2012; Brasher, 2020). Yet, embracing vulnerability and sharing these personal experiences of fieldwork contributes to academic learning (Punch, 2012; Brasher, 2020; Rüller et al., 2020). For these reasons, in addition to my fieldnotes, I kept a field diary, which I coded thematically following methods by Punch (2012). This section first reflects on my positionality/reflexivity, then on the salient themes that arose from my field diary. These are important parts of my thesis because they contribute to the wider academic knowledgebase about the challenges of fieldwork.

5.7.1 Positionality & Reflexivity

The relationship dynamics relating to my positionality varied based on where and with whom I was engaging as I moved through different communities. The dynamics were mainly due to relational power, influenced by wealth, race and gender – these dynamics are based on my perception and assessing the extent of their power is subjective and contestable (Luke, 2021). I had three main roles during the fieldwork: a) as a white woman ‘muzungu’ visiting women and local residents within the community; b) as an early-stage and young female researcher requesting interviews from powerful political and academic figures; and c) as a female intern conducting trials at the large industrial fish farm, Victory Farms (VF).

Within the community, my position as a white woman most prominently affected the research. While the community occasionally saw white people, it was usually in the context of a development project, aid agencies offering donations, or the local fish farm. Thus, my whiteness made people automatically associate me with money and a potential source of funding. Through these associations, my whiteness facilitated access to people, through their curiosity and perhaps optimism that I could provide money. Being a woman also probably enabled access to private spaces, like homes (although it did at times, affect my sense of security while traveling around). In public spaces, my skin and comparative wealth drew significant attention. This prevented me from positioning

myself in the interstitial spaces, and I was unable to remain an observer despite my position as an outsider (Mulcock, 2001). My presence was glaring. On the other hand, this facilitated participant recruitment, as people were curious to “meet the muzungu”. My gender also assisted recruitment and trust development, as “a woman’s power is never seen as serious, as threatening, and as distancing as a man’s” (Colic-Peisker, 2004: 88).

My presence affected my study group’s behaviours (also experienced by Kurotani, 2004, during her fieldwork on women Japanese homemakers in the USA). In private interviews, my race affected the stories’ focus. For example, our translators believed that my presence made people talk about school fees more frequently, hoping for contributions. This led us to deviate our research and spend time on lines of inquiry about school fees in the quantitative work. Because school fees were so prominently featured in the interviews, I added a line of inquiry about the impact of school fees on food security. Based on the interviews, I hypothesized that the legal requirement to pay school fees might be detracting from funds that could otherwise be spent on food purchasing. Yet, no correlations were found. I wonder if struggling to pay school fees would have been brought up so frequently had I not attended the interviews.

My whiteness was a stark visualisation of Kenya’s colonial history and resulting racial and economic inequalities that persist. My privilege and the constant reminder of it felt both awkward and guilt-ridden as I requested participation. I was emotionally motivated to avoid extractive practices and colonialist research because,

The injustices of colonial histories have resulted in significant ongoing power differentials between many indigenous and nonindigenous communities around the world. (Harvey, 2004: 179)

Anthropological complicity in the colonial endeavor has especially fueled this disciplinary self-critique, as has heightened suspicion of anthropological motives in the postcolonial era. (Shuttleworth, 2004:47)

A popular decolonisation approach is to write from the perspective of the indigenous voice/experience – as a white woman, I cannot do this. Instead, I attempted to preserve the participants’ words as accurately as possible. While some of my research was observational, I relied on participants to recount their lives to me and took their perspectives as reflecting their reality. Throughout, I reflected on my activities to avoid retreating into claims of superior objectivity – i.e., maintaining that participants know themselves and their lives better than I do. Within the analysis of their words, I considered dramaturgical theory: the idea that people conduct themselves differently depending on the context (Goffman, 1959). Producing and delivering printed copies of the *Voices From Sindo* book for the community was one way of avoiding extractive research (Pounds et al., 2024). The poetry book reproduced knowledge in the same way it was provided to us as researchers

and to give back to the community, avoiding parasitic research. Dissemination plans for the results of this thesis will also deliver results of the research back to the community and contribute towards impact.

From the outset of each interview, I aimed to reduce the effect of the inequalities. All participants were reminded that their participation was voluntary, and that they held the decision-make power over what data was included and shared. Despite my attempts to use informal and relaxed language to gain participant trust, participants treated the interviews as extremely formal. The consent forms and introductions enforced this formal tone. But, when I saw the participants afterwards, I was greeted as an old friend and sometimes even with a hug. This reassured me that the interviews were going well and people did not associate me with discomfort.

In contrast for youths, the aim was to reposition myself as a facilitator to their ideas rather than as an ‘instructor’ or similar authority figure. We began with introductions and played a fun ‘icebreaker’ game, using goofiness to reduce the intensity of the power differential between us. While the power differential was reduced, removing it completely was unavoidable, due to embedded racial, educational, and generational inequalities within society. At first, youths were shy and many resisted contributing to the exercise where we co-developed aims of the PhotoVoice project. By the time they presented their photos, youths were clearly more confident and outspoken about their ideas. While subsequent informal interactions with them were not ‘friendly’ like with adults, youths continued to seek communication with me to tell me about their work and request updates on my research.

My second position was as an early-stage and young female researcher requesting interviews from powerful political and academic figures. The aim was to interview them before local residents and women, to acknowledge their position and seek their consent to conduct research. While talking to them first and their consent was not officially required, local customs suggested it would facilitate access and be considered polite. Yet, many of these potential political and academic recruits were inaccessible. For instance, one suggested that I interview his secretary instead. Several failed to show up to appointments or cut off their interview early. Another spent our time together explaining why I should be researching Nile perch instead of omena. Generally, they dismissed omena as a poor person’s food and an irrelevant fishery, instead focusing on Nile perch and tilapia and the plight of being a fisher. They avoided talking about the community broadly, instead describing the barriers and difficulties that Nile perch and tilapia fishers encounter. I wonder if I had returned to them with my results on omena (presented in the discussion chapters), if perhaps richer conversations would have emerged. For these reasons, I failed to obtain representative data from BMUs, government, and local academics. On the other hand, significantly more data was collected from women in the study area, a historically subjugated and overlooked demographic.

My third role was as an intern at Victory Farms. In the absence of formal PhD funding, being an intern conducting feed trials at Victory Farms was critical: engaging with Victory Farms

economically enabled my visit to Kenya and physical access to the study area. They provided accommodation and food on-site, offering partial rather than complete anthropological immersion in the community. On the farm, VF gave me responsibility over the trials, expecting me to notify them of major changes or issues when necessary, but mainly trusting me to manage. Off the farm, VF gave me ‘free reign’, never asking or needing to be involved in my off-farm research in any way; however, I did keep them informed of my general research questions and activities. Adhering to their residents’ security rules presented complications and required adjusting the timing, planning, and actioning of my fieldwork. For instance, I was prohibited from many areas due to high crime rates and was required to have a male companion when off-site. My research was aimed at understanding a wide range of socio-economic conditions and a few targeted study areas were abandoned due to their advice and travel restriction advisories, which I was compelled to adhere to as part of the University’s travel risk assessment requirements. Ethical dilemmas presented by exclusion of vulnerable groups from research due to safety risks to researchers has been documented (Tourigny, 2004; Ghosh, 2018).

My relationship with VF affected the way participants decided to portray themselves and their lives to me. Often at the end of interviews, participants would ask me if I could help their relative get a job at VF. Despite making it very clear from the introductions that I was a research student from the University of Stirling and not an employee of Victory Farms and the participants had no way of knowing that my accommodation was at Victory Farms, my whiteness branded me as connected to Victory Farms. This meant that the participants’ shared opinions about fish farms may have been presented according to their perception of me; therefore, their opinions were validated in the quantitative questionnaire.

My relationships at the farm influenced my state of mind and thus affected my overall experience. Like engaging with academics and locals in positions of power, being a woman was a barrier to trust building with the trials team, who were local residents. Luckily, I quickly built a rapport with the trials lead: I communicated my research needs to him and he would action those needs through his existing relationships within the company. I interfaced socially with farm managers, who were from the international ‘expat’ community. Being an ‘insider’ among the small group of expat ‘outsider’ managers gave me an immediate community and support network providing a refuge from the sometimes harsh and uncomfortable realities of ethnographically informed fieldwork (Corsino et al., 1987; Beckerleg & Hundt, 2004). At the same time, the relative importance of my research work (both on and off farm) was inconsequential to commercially oriented activities and farm targets. My existence on the farm often felt superfluous when we engaged in work-related conversation (contributing to my academic anxieties – see below). In these ways, my residence at the farm provided both a barrier to and a refuge from the community. My field of operation was certainly transient as I moved between worlds (the expat world and the community).

5.7.2 Field Diary Themes

As a result of coding and conducting a thematic analysis of my field diary, three main themes emerged:

1. Intersectionality: financial relativity, white guilt, and feminism

The relativity of wealth was a prominent consideration and concern throughout my relationships and fieldwork experiences, mainly while engaging with community residents. As a self-funded PhD student, I often had anxiety around my own finances and juggling paid work alongside research. Although I consider myself part of the British middle-class, my participants positioned me as upper-class. Their relative poverty compared to my northern-European privilege was exigent for all of us (Punch, 2012). They commented on the quality of my shoes and bag, and gently probed about whether I could buy and give them clothing. Confusion arose because I lacked certain local indicators of wealth. For instance, most of my participants owned land and were shocked to learn that I did not own nor would inherit land. A juxtaposition existed between my own identity, the poverty of my participants and research team, and the different wealth indicators. Therefore, a large portion of my diary explored meanings of wealth and its implications for me as I moved from a middle-class existence in Scotland to an upper-class life of luxury in Kenya. The juxtaposition also gave me a greater appreciation for use of a physical wealth index rather than economic indicators and its importance in measuring wealth as relative and context specific.

Awareness of my relative wealth was accompanied by significant guilt. I felt anxiety about taking up too much of participants' time and I worried about extractive research practices. People – not just my participants – often asked me for money, both directly and indirectly. Participants were more likely to ask me for solutions to the food security issues we discussed; but I was unable to speak from experience and my theoretical responses quoting the academic literature felt insufficient. While my research topic is critical and contributes to the literature, I acknowledge that it lacks direct or immediate impact on my participants. Some participants gave me gifts; for example, I left one interview stuffed with rice and potatoes and another with a live chicken. I felt guilty receiving these valuable food items and grappled with whether it was more ethical to refuse or accept the gift (similar quandaries are presented by Punch, 2012). Participants under poverty-derived distress offered us their valuable time, sometime without, but often with expectations. I was unable to give my participants what they asked for: irrigation systems, a job, fish, or advice on growing cabbage. I could just promise that their requests would be documented and included in the research. One particularly poorer group of women became angry at the end of their interview when I gifted them sanitary pads – a pregnant woman replied with indignance, “We just told you that we’re hungry and you give us pads? We cannot eat pads. We want maize.” My guilt led me to return the next day with maize.

Thereafter, all participants received a food gift at the end of the interview or survey. This was usually a 500g bag of sugar for longer activities or a soda for shorter activities. Generally, compensation for participation in research presents ethical issues (Beckerleg & Hundt, 2004; Biruk, 2017); however, offering my participants nothing presented greater ethical concerns considering our relative wealth differences. In my diary, I reassured myself that, as a researcher using anthropological methods, I aimed to observe, not intervene. Yet I questioned whether realigning myself with research was a self-serving approach: I reasoned, “me giving them food or money will not help their poverty status” (14 June 2022). Sugar was a compromise, a little luxury, a show of gratitude, and compensation for lost earnings during the interview time. I aimed to follow local customs to gain trust and build relationships – this included providing gifts to visitors and hosts. Sugar consoled everyone, though it symbolised a host of ethical questions.

The correlation between my relative wealth and my race also created guilt feelings. In the United States, psychologists and sociologists may refer to this as ‘white guilt’ (Steele, 1990; Swim & Miller, 1999). ‘White guilt’ refers to the guilt feelings white people can face when recognising the ways that they benefit from racial legacy and injustice. In my diary, I often questioned my research topic and whether I, as a white woman, was appropriately positioned to research it. I interrogated my motives, critically assessing if I was engaging in colonial research. Indeed, requesting and receiving data from people who have much less than I did, for my own academic gains tasted like colonialism. I also inquired whether I was drawn to this research topic as a ‘white saviour’, defined as,

For those Western oppressor-class folk that seek out employment in development, this privilege often exhibits itself as a sense that we as Westerners have the unique power to uplift, edify and strengthen... This idea that it is the role of the White outsider to ‘lift’ the poor and oppressed in developing countries seems universal in the Western world. (Straubhaar, 2015: 384)

This reflection was a counterforce to my guilt, in the sense that actions in response to my white guilt were in opposition to avoiding acting as a ‘white saviour’. For instance, white guilt led me to bring the poor women maize, placing me into a ‘white saviour’ position. Holding these elements consciously still feels insufficient to adequately address these issues; however, despite our best intentions, being in the field can cause harm despite our best intentions and attempts to minimise it (Brasher, 2020).

My racial privilege was compounded by my relative wealth, my advanced degrees, and connections to Victory Farms, yet alleviated by my gender (Straubhaar, 2015). As mentioned above, I benefited from this privilege because it permitted access to local participants, who may have felt coerced to partake due to my powerful position granted by my race and wealth. I was unconscious of this dynamic at first, instead excited that locals were so open about sharing their experiences. Greater awareness followed after reflecting that the opposite experience was also apparent, where I was

denied access to local government officials and academics due to my position as an early-stage female researcher. Thus, reflexive action was taken to avoid oppressive research practices. For instance, the choice of “in vivo” coding was intended to preserve the participants voice and avoid superseding it with my own (Saldaña, 2021; Musyoka et al., 2023). Later in the research, asking for buy-in from the elders and youths in participatory methodology was an attempt to declassify myself as the ‘expert’; this was not successful because my position prevented them from being forthcoming, despite my verbal prompts. Longer-term relationship building would have addressed this issue, where aims of the research would have been co-developed after a longer period of deconstructing and alleviating these power imbalances. Self-reflection and field diary analysis has developed ‘critical consciousness’ and problematisation of my role in this research (Straubhaar, 2015). It will certainly inform improved methodologies and approaches in my future research.

While my race and wealth positioned me powerfully, my gender created barriers concerning the practicalities of fieldwork. This consideration of intersectionality – defined as,

How intersecting power relations influence social relations across diverse societies as well as individual experience in everyday life... Intersectionality views categories of race, class, gender, sexuality, nationality, ability, ethnicity, and age as interrelated and mutually shaping one another. Intersectionality is a way of understanding and explaining complexity in the world, in people, and in human experience. (Collins & Bilge, 2020)

As mentioned, I believe my gender blocked access to data from fisheries officers and other men in positions of political power. In my field diary, I felt extremely frustrated from barriers resulting from systemic misogyny. Indeed, I admit with some degree of shame that I was much more and more often bothered by gender-based barriers than I was about privileges granted by my race and wealth. Additionally, my gender influenced my perceived safety in the community: while male residents of Victory Farms were granted free mobility, female residents had limitations on their movements. The high rates of local alcoholism, HIV, and domestic violence, coupled with the attention garnered by our whiteness, created worries about women’s physical safety.

Their concerns did initially give me unease when in the community, although this quickly faded with increasingly positive experiences of fieldwork. The closeness that generated unease may also have rendered insights: for example, empathy with women in violent domestic households. Perhaps emotionally confounded with my own experience, I also felt indignation and sadness at my female participants’ suppression. My field diary was commonly used to express my personal reactions to my participants’ stories. Triggering stories came from both men and women. For instance, women recounted personal experiences of domestic violence. One man asked me about my own life: when I shared that I was a bad cook, he scolded me to “be a better wife, or your husband will have a good

reason to hit you”. I hoped that allowing my personal reactions an avenue of expression would allow me to remain observational and impartial in my fieldwork.

Nevertheless, my own feminist beliefs coupled with gendered barriers certainly affected my work. I ultimately spent more time with women in the community. This certainly led to a lack of understanding of fishers’ experiences. However, fisher experiences are more common in the literature and my greater focus on the experiences of omena dryers and local women is not necessarily regrettable considering that the latter is lacking from the literature. But I question: Did I subconsciously avoid male participants and “privilege the subaltern” in my research through my interest and ability to empathise more easily with the women (Corsino, 1987; Forsey, 2004)? Though I did not approach this thesis with feminist or even gendered objectives, gendered analysis emerged from the data. I wonder how much my personal feminist values and personal reactions subconsciously affected my focus. Regardless, on-going reflection and deconstruction of my experiences and position has been invaluable and will be essential to future sociological research.

2. Poor health and food experiences

A recurring complaint in my diary was about food and digestive illnesses. I struggled to get the diversity of fruits and vegetables to which I was accustomed at home. While I enjoy a variety of cuisines and have not identified as a “picky eater”, the monotony of the local diet bored me. Additionally, food poisoning and digestive issues were regular occurrences. My diary reflects that I planned meals and activities around each other, sometimes skipping meals if I had a critical activity that I did not want to risk missing or rescheduling due to illness. I was not alone: my participants and research team regularly fell ill to digestive illness. My diary showed awareness that my practice of self-care was undetachable from the unfairness of my privilege. Local food hygiene was poor, although this was not a focus of my research, it certainly has implications for food security and wellbeing. Poor digestion can impair nutrient bioavailability with severe health consequences (Richards et al., 1993). Therefore, local research and interventions on food hygiene as a component of food security is warranted. My experiences around food led to assumptions and biases around the likelihood of nutrient deficiencies (see Chapters 7-9).

3. Academic Anxiety

Concerns about the academic quality of my fieldwork were pervasive, as experienced by Punch (2012). With a background stronger in technical trials, my lack of anthropology training was awkward in academic circles. Yet my research required a multidirectional approach to understanding not only the nutritional science of producing and increasing access to fish as food, but also the experiential elements of fish acquisition / consumption. I am not an anthropologist, but elements of anthropology were necessary to my research. I had no ambitions to completely explain and become immersed in my study area, as ethnographers do. I was afraid that academics in “technical” research

would disrespect my anthropological approaches, while anthropologists would criticise/question my lack of “full” integration with my participants. There was a jarring disconnect between where my participants lived versus where I lived at the farm, and thus I criticised my fieldwork as “not real”. Complete immersion was impossible considering the funding structure that enabled my fieldwork (the on-farm feed trials), although it would certainly have given me greater insights into local food experiences and practices. My academic doubts were punctuated with additionally feeling time-bound and pressure to complete everything within my visit. Managing both on and off farm research responsibilities while also doing paid work was a major topic most days. Transportation was also a limiting factor to time spent in the field: for instance, rains could make roads impassable and taxi services were unreliable. As a result, people (including me) were often late for or cancelled appointments last-minute, adding to my sense of time urgency.

Reflections on my relationships with my translators was a significant subject I perceived to influence academic rigour (Fathi, 2013). Managing expectations with my first translator was difficult and we ultimately did not continue working together. She sought out the role and was eager to help translate and recruit; however, her position as a Chief’s daughter introduced additional power dynamics that, combined with my own position, were difficult to address. She scheduled interviews without communicating with me first and she often brought me to her family members to interview. Furthermore, when she added or changed questions in my interview, I felt I lost some control over the sampling and interviewing methods. Thereafter, I lacked trust in the accuracy of her translations. Being unable to speak Duluo nor Swahili, I had no way of verifying translations. To address this issue, I quickly decided to work with two translators at once, so that they could collaborate and improve the accuracy of the translations. Having two translators also minimised amplification or distortion of participant voices due to their personal translations and perspectives. Thus, after awkwardly ending the relationship with my first translator, I was introduced to another translator who did not have a local position of power. She recruited her friend, who also had excellent language skills. The level of trust in my new translators was critical and we spend significantly more time in training and verification to attempt rigorous data collection.

The relationships with my two translators – Sally and Carol – was an additional site where we navigated racial and wealth power hierarchies (Straubhaar, 2015). The women were fun and our relationship straddled the line between employee-employer and friends. Upon reflection, I see that I used my privilege to be friendly when it was convenient for me, but pulling out my employer position when I needed something from them (Straubhaar, 2015). The degree of our friendship was also amplified when it benefited me – I felt pride that I was alone among the Victory Farms ‘muzungus’ (the local term for white people) who took the time to engage with the community on a personal level. I was clearly taking advantage of my position in ways that benefited me – habits that should be monitored, continuously reflected upon, and avoided during future fieldwork (Straubhaar, 2015).

Sally and Carol were essential as translators, but also as my guides and key informants (Reyes, 2020). They knew the area, what was safe, and ensured that I avoided social faux pax. The elders spoke in Duluo and Swahili and, as I was unable to understand either, I was dependent on Sally and Carol to complete the research. This meant that I needed to develop a degree of intimacy and reciprocity with them. I needed to trust that their translations were accurate and for them to trust me with nuanced or sensitive information, particularly information that may not have been verbalised (Temple & Koterba, 2009). As a visitor, I relied on them to translate even non-verbal cues. My translators' trust in me – of receptivity, support of them, and prioritisation of their wellbeing – was not only ethical but also critical to the research. As was an understanding of their positionality, which we discussed together throughout fieldwork: certainly, their positionality as insiders and their first-hand knowledge of the study area affected the research (Tschunkert, 2021). Sally and Carol's own reflections can be read in *Voices From Sindo* (Pounds et al., 2024).

Conducting the research in English with Duluo/Swahili speakers required careful consideration of how nuanced meaning becomes translated (Temple & Koterba, 2009; Fathi, 2013). While none of the elders chose to speak in English, the youths were more confident in English due to curriculum and education differences between the generations. Many youths bravely chose to communicate in English as their second or even third language. Had they communicated in Luo, they might have been able to use words more accurate to their exact experience; at the same time, they would have given up control over the translation. They may have chosen to use English as a form of agency over their stories.

Some of the participants talked directly to me while others talked to the translators. Sometimes the participant would go back and forth. Under Dramaturgical theory (Goffman, 1959, as cited in Kivisto & Pittman, 2007), we understand that this may have affected how participants portrayed themselves – on the one hand, they were being approached as authorities and representatives of the Sindo community; on the other, they were positioning themselves as needing of help and receptive to gifts. How much of the latter was due to my presence as a potential funder versus the community's habitual courtesy of sharing gifts?

Ultimately, my fieldwork experience was wrought with awkward, frustrating, angering, frightening, sad, compassionate, and funny moments. All of these evoked strong emotional reactions in me, which were important to reflect upon before acting during both the fieldwork and the analysis (Brasher, 2020). Indeed, informed retrospection, self-examination, and interrogation of our motives and actions as sociology researchers is a key part of learning (Straubhaar, 2015).

Participant observation is thus an intensely humanistic methodology based almost entirely on the messy, complicated, and often emotionally fraught interactions between two or more human beings, one of whom is the researcher. (Hume & Mulcock, 2004:xviii)

Chapter 6: Fisheries livelihoods for whom? Gendered and generational considerations regarding fisheries livelihoods on the Kenyan shores of Lake Victoria.

This study aimed to describe locals perceptions of the fisheries value-chain, the gendered dynamics within it, and local livelihood aspirations. A focus on the omena value-chain (*Rastrineobola argentea*) emanated.

6.1 Methods

The results in this chapter were mainly derived from the qualitative work using inductive analysis (methodology described in section 4.1), a WEIA (Women's Empowerment in Agriculture) survey tool, and dietary diversity scores, which are now explained.

6.1.1 WEIA (Women's Empowerment in Agriculture) questionnaire

Because findings from the qualitative work suggested that female autonomy may be related to their food security, this survey included questions to generate a 'Women's Empowerment in Agriculture' (WEIA) score (IFPRI, 2012; Myers et al., 2023). The WEIA has previously been used in Western Kenya (Diirro et al., 2018). WEIA was chosen over the Women's Empowerment in Fisheries Index (WEFI; Ragsdale et al., 2022) because a larger portion of the population engaged in agriculture (38.6%) than fishing (26.6%) or the omena business (18.1%) as found in the household survey (Chapter 7). The WEIA score per female head of household was calculated using methods by IFPRI (2012).

6.1.2 24-Hour Dietary Recalls

The questionnaire included individual 24-hour dietary recalls, where the respondent recalled everything that they ate yesterday (i.e., the day prior to the survey day). Because the qualitative work found that households ate from the same pot and intrahousehold differences in the *types* of foods consumed were low, it was assumed that the male or female head of household's diet would be representative of that for the entire household. Differences in *quantities* of foods consumed was explored in the "dinner intake" study (for more details see 7.1.2).

Most dietary intake studies use a 3- or 7-day food consumption frequency questionnaires (i.e., how many days this week did you eat each of these food categories?) or, to a lesser extent, 24-hour recalls (Casey et al., 2024). While food frequency questionnaires are more suited to capture foods that are less frequently consumed (Casey et al., 2024), a 24-hour recall was used instead in attempt to gather

data on quantities of foods consumed⁵. Other studies in Kenya have also used 24-hour recalls to examine dietary patterns (Hansen et al., 2011). Furthermore, this study area was known to eat fish frequently and throughout the year; thus their consumption could be captured within a 24-hour recall. Regardless, single 24-hour recalls do not capture seasonality between species and may misestimate fish consumption at the species level (Casey et al., 2024). Ideally with more resources, recalls would have been repeated monthly over the entire year to understand seasonality of fish consumption and triangulated with 3- or 7-day food consumption frequency data.

6.1.3 Dietary diversity indicators: economic and nutritional dietary diversity scores

The 24-hour dietary recalls were converted into an ‘economic dietary diversity’ score (‘Household Dietary Diversity Score’ or HDDS), which indicates households’ economic access to a diverse array of foods (Kennedy et al., 2011). The HDDS consists of twelve categories, and a target HDDS score for the community is calculated by taking the average HDDS of the 33% of households with the highest HDDS scores (Kennedy et al., 2011).

The 24-hour dietary recalls were also converted into a ‘nutritional dietary diversity’ score (‘Minimum Dietary Diversity Score’ or MDD-S) score, which reflects the probability of nutrient adequacy (FAO, 2016). Respondents with an MDD-S score of five are more likely to have nutritionally adequate diets (FAO, 2016). Each ingredient listed in the 24-hour dietary recall was assigned a category based on the HDDS and MDD-S categories (as distinguished by Kennedy et al., 2011 and FAO, 2016, respectively). Then, the total number of categories listed for each household was summed. For example, if a household ate only omena (an animal source food), leafy green vegetables (a vegetable), ugali (a grain), and porridge (a grain) their MDD-S score was three. Both the HDDS and the MDD-S were used because they measure affordability and adequacy of the diet, respectively: the HDDS indicates the possibility that a household has the ability to afford a diverse array of food, whereas the MDD-S indicates the likelihood that a diet is nutritionally adequate based on the diversity of that diet. These different measures are important, as the HDDS examines economic factors whereas the MDD-S can be driven by a variety of factors.

Households were randomly selected by the enumerators by walking through downtown Sindo and asking every third house if they would be willing to participate in a survey. The female head of household was asked the WEIA questions. If the female head of household was not home, the enumerator would move to the next house. In many cases, the household would request that the enumerator return later when the female head of household was home, and enumerators complied.

⁵ I originally used 24-hour recalls and asked about quantities of food consumed so that I could calculate micronutrient intake; however, respondents were unable to estimate quantities, thus the 24-hour recalls were converted to dietary diversity scores to not ‘waste’ the data.

Data for the WEIA questions was collected using a mobile application designed for remote data collection (Lakshminarasimhappa, 2022).

6.2 Results

6.2.1 Results of the qualitative inductive analysis

Gendered livelihoods: “Everyone is equal... but we are very different.”

When asked about food or livelihood differences between demographics, almost all respondents said that “everyone is equal”. Several people added that everyone was equal under the most recent revision of the constitution in 2010. However, a variety of differences were divulged through the pursuant conversation. Mainly, respondents described welfare differences between wealth groups and gendered labour responsibilities (Chapter 7 explores this further using quantitative data). Respondents may have initially responded that everyone is equal because, while gross inequalities indeed existed, they were normalised, minimalised, or assumed. When asked to elaborate on why key respondents said everyone is equal, but listed so many differences, one woman tried to explain,

Fingers are different, but rich and poor feel the same – our children all go to school... Everyone is a scholar. Even me. Even you. (A wealthier middle-aged woman in Sindo)

In this quote, she was directly describing the rapid improvements to education access in Kenya, which she and others have attributed to increased gender equality (Mule, 2008). This generational shift was apparent among the respondents: whereas all men and young women chose to communicate in English (part of high school curriculum), adult women chose to speak in Duluo or Swahili. Gender inequalities have continued to reduce: for instance, while women have a higher likelihood of falling into poverty, the poverty rate decline in Kenya was higher for women than men (Ichwara et al., 2023).

When asked about the differences between what men and women eat, key informants initially responded that “men and women eat the same” because everyone eats from the same pot of food. Generally, attitudes around food were community-oriented and food sharing was valued: as one key informant described, “When you serve, you mind the other person... you eat knowing the other person has not eaten.” Thus, the food available for that day was portioned so that everyone could eat. Other studies have found that other traditional African households share food from a common pot rather than eating alone (Okoror et al., 2008). Sharing from the same pot is symbolic of the solidarity and ties between those consuming the food:

The significance of food goes beyond the act of eating to include group sharing of food From the same bowl, a representation and preservation of socio-cultural processes, and a symbolic means of describing both familial and conjugal relationships. (Okoror et al., 2008: p. 210).

Okoror et al. (2008) described that women's traditional roles as nurturers were validated by family acceptance of the food the women prepare. Indeed, portioning, serving and cooking food was important and controlled by the female household head, as also found by Ogoye-Ndegwa & Aagaard-Hansen (2003), Beuving (2010), Owino (2019), and Bukachi et al., (2022).

While household members all ate the same dishes, different household members were served different parts of the ASF. Male heads of household were served first and were given the best and most food due to the family's perceived reliance on their labour for their livelihoods. As one woman described, "My husband must eat well to be satisfied because he brings food to the table." Furthermore, men, women, and children typically received different portions of the fish. Children received the tail, whereas male heads of households received the head due to its perceived value (this contrasts with Nigeria, where children were given the fish head because it was perceived as more time-consuming and messier to consume: Gomna & Rana, 2007). In the present study, chicken consumption was likewise gendered: children were served the wings, head, and neck, women were served the breasts, and men were given the thighs, buttocks, and gizzards. As for beef, men were served the cow's head. Generally, in western Kenya, men are given choice parts of chicken and fish due to their position as household heads, the prioritisation of their satisfaction, and the perception that their off-homestead labour is heavier and harder work than domestic work (Owino, 2019; Bukachi et al., 2022; Musyoka et al., 2023). This dynamic was also found among Luos in urban settings (Bukachi et al., 2022). In contrast to other studies, key informants did not identify any restrictions on women's consumption: for instance, Musyoka et al., (2023) reported that women's chicken consumption is restricted to protect income resources. Low consumption of ASF and protein malnutrition in other Luo communities has been attributed to inequitable food allocation influenced by male favouritism, taboos about women and children's consumption of eggs and parts of chickens and meat, and religious beliefs (Owino et al., 2019; Bukachi et al., 2022; Musyoka et al., 2023).

Yet, respondents noted that many people were no longer following these conventions. While women are still generally considered responsible for cooking and men are responsible for income provisioning, key informants said this is changing too. Some people distribute the different parts of the ASF unconventionally and some younger men cook. This trend also occurred in Uganda (Beuving, 2010) and Mombasa, but at a faster pace, driven by male migration that forced men to take on household responsibilities (Smart, 2017). But like in Mombasa, key informants described that both men and women still perceive that cash provisioning for the household was the male head of household's responsibility. Ogoye-Ndegwa & Aagaard-Hansen (2006) also observed that traditionally, men are expected providers and women are carers, and wives were mocked when their husbands do not provide enough money for food. However, women reported that income from only the male household head is insufficient to support their household's food security.

Men who work away from the homestead and/or share time between households, may be removed from the realities of food security in each homestead. This was apparent in the conflicting stories from male and female households, where men perceived that women were food secure.

Women who are here can never lack what to eat because they are at one time or another engaged in an activity that can generate it. (Male fisheries governance representative)

Other male key informants perceived that “women control food” and “women never lack to eat”. In contrast, women said that they had insufficient cash for food purchasing for their household. A focus group of female omena dryers agreed when one of them said “Our husbands beat us [because] he hasn’t left money for food.” They explained that they relied on their husband to supply cash for food purchasing and when he failed to supply cash, they also failed to provide dinner, which he beat them for. Some men far from the lake in an agricultural area related that they locked their grain stores so that their wives could not steal grain to eat or sell while they were away from the homestead, evidencing that crops were grown for selling rather than consumption (quantitative analysis on this is shown in Chapter 7). Gender conflicts among Luos are worsened by unemployment, social disorder, and disease epidemics (Price 2008), all of which existed in the present study area.

Potentially as a result, women’s roles have recently begun to shift from domestic to off-homestead income-generating activities to increase cash available for household spending. When asked about the differences between men and women’s livelihoods, most key informants automatically replied, “men and women are the same” and “both genders can do anything”. For most households, key informants relayed that everyone was now responsible for income generation. Both men and women participated in activities like shore fishing, store-keeping, second-hand clothing sales, restaurant operations, and gardening/agricultural labour. In contrast, wealthier residents narrated that men were responsible for bringing in money, whereas women were responsible for cooking, farming, and fetching firewood. Wealthier respondents may be able to afford traditional gender roles. For women who did participate in income-generating activities, their traditional responsibilities at the homestead persisted and, unlike men, women continued working outside of their income-generating activities. Thus, most women were provisioning and preparing food for the household. This overburdening of women was also described in urban Kenyan settings (Smart, 2017).

While both men and women were working and people felt like genders had equal opportunity, income-generating activities within the community were actually quite gendered, particularly within the fisheries value-chains. Men’s activities included offshore fishing, net-mending, charcoal-making, bodaboda (motorcycle taxi), and brick/stone-making. Within the fish value-chains, men dominated boat and business ownership, fishing, and transport, while women participated in processing and some trading. Both male and female key informants noted on several occasions that “women cannot go inside the lake” and “going to sea is purely men.” While both men and women participated in

trading, women dominated value-adding and sales, selling fried or dried tilapia and small Nile perch in local markets. Women's engagement in processing was also apparent in Zambia (Abbott et al., 2015; Mussa et al., 2017; Ragsdale et al., 2022), Ethiopia (Alemu & Azadi, 2018), the Tanzanian side of Lake Victoria (Onyango, 2017), Congo (Béné et al., 2009), and Malawi (Mussa et al., 2017; Manyungwa et al., 2019; Bennett et al., 2022). During the Nile perch export boom, women were employed in Nile perch processing and many lost those jobs with the declining Nile perch export trade (van der Knapp & Ligtvoet, 2010). Some of these women transitioned to omena drying, which was lower-value and higher risk: omena drying is an independent business, contrasting with relatively more secure employment at a processing plant (van der Knapp & Ligtvoet, 2010). Key informants in the present study confirmed that now, omena processors and traders were almost exclusively women.

Women were limited to the lower-value fish and omena sales, Nile perch and tilapia trading (for bandas), and omena processing nodes; they were largely excluded from higher-value nodes (e.g., boat ownership, transporting, bandas) within the fish value-chain. Women's marginalisation within the fish value-chains and exclusion from higher-value nodes of the fish value chains were also apparent in Malawi (Manyungwa et al., 2019). In the present study, conducting trades between fisher and banda owners was risky, considering that the traders' profit depended on the difference between the set price of the banda owner versus the fisher. Some days, traders did not make any profit whatsoever. Participation in the omena value-chain was also riskier than the fish value-chain because the omena fishery productivity varied significantly with the lunar cycle, resulting in monthly price volatility, for both omena dryers and their consumers. Considering that dried omena can be stored for three months, storage solutions for omena dryers to stockpile their dried product during abundant periods for sale during leaner weeks is a potential intervention that might smooth price volatility. While the Nile perch and tilapias value-chains varied seasonally, fish prices were regarded as more stable and did not vary with the lunar cycle. In particular, omena dryers were identified as a nutritionally vulnerable group. These were almost exclusively worse-off women who were marginalised by a lack of political representation or cooperative groups.

Despite its lower value and higher risk, the omena drying business was an accessible income-generating activity for worse-off women that gave them their own financial income and thus control over their lives (Figure 24). Indeed, omena dryers relied on the omena drying business for income. The activity was easy entry: with only a basin and a thousand shillings, anyone could start their own omena drying business. The business could be run close to the homestead, which was important due to family dynamics prohibiting women's migration.

There are many jobs at the floral companies in Naivasha, but our husbands will not let wives leave to find work. (Young female omena dryer in Sindo)

Husbands control over women's income-generating activities was also observed in Malawi (Manyungwa et al., 2019). In the present study, these typically worse-off women felt that omena drying gave them financial control they would otherwise lack if they were to rely on their husbands' income or foraging. One omena-drying woman in Wadiang'a said, "It's my own business". Some women decided to hire other women to help fetch the omena, considered the most labour-intensive part of the job; others believed it was better to do everything on their own to maintain total control.



Figure 24: Female omena dryers sit near the market, chatting and waiting to sell their dried omena from basins.

Despite the accessibility of the omena drying business and the financial benefits it provided to women, omena dryers and omena fishers (i.e., those part of the fishing crew) engaged in gendered power struggles. In Tanzania, competition for omena is also high and some women make pre-arranged agreements with omena fishers (Moreau & Garaway, 2021). These struggles in the study area were apparent in the elasticity of landed omena price per kg and the 'sex-for-fish' practice, mentioned by both omena dryers and fisheries government representatives. 'Sex-for-fish' is a well-documented practice among fishing communities around Lake Victoria, where some women – often the worst-off – exchange sex with fishers for the right to purchase fish from them (Camlin et al., 2013; Fiorella et al., 2015; Kwena et al., 2017; Fiorella et al., 2019). Sex-for-fish came up in several of the interviews with government representatives, where it was framed as coercive prostitution. These key informants described how fishers refused business with noncompliant women. Even

women who did comply were sometimes refused business anyway. The fishers were more powerful, since they controlled the fish. The politician said, “These women are used like objects.”

Sex-for-fish also came up in one of the focus groups with omena dryers but was framed differently. The following excerpt from my field journal illustrates the encounter:

The women were lively, and all appeared to be in their early twenties. As the women became comfortable, the focus group felt more and more like a women’s catch-up chat.... After the formal interview ended and the recording had been switched off, the women brought up that men could practice polygamy and have several wives and women could only have one husband; however, women had their own, less official version. They could have lovers and boyfriends on the side. There were several knowing and cheeky smiles across the room. Then, they described the “pookiye” men, and Sally [my translator] explained that it was a local term that translates to “use and dump men”. The catch phrase “love them and leave them!” came to my mind. They described that relationships with pookiye men were common. When we asked these relationships had benefits, the women laughed, describing how they convinced pookiye men to fall in love with them and bring them free fish and sell them plenty omena. When asked if these relationships felt good, the women finally fell silent, and the ethos of the room dramatically shifted from jovial to solemn. One woman’s forehead was scrunched and she looked angry. After a while, one woman said, “We have no choice.” (31 Mar 2023)

This final comment is explicit: the women felt they have no choice but to engage in the sex-for-fish transaction. Yet, their story infers that they do so to gain advantage, rather than being coerced into sex with fishers. This exchange contrasted with the government officials’ and any framing that positions the women as completely powerless; these women were able to exert ‘thin’ agency, described as agency with constraints (Klocker, 2007). The situation is complex, as Kwenya et al., (2012) found that these women lacked bargaining power to refuse or negotiate for safer sex practices. Regardless, sex-for-fish has been, but should not be discursively confused with sex work, which positions women traders as victims and minimises their role as economic actors within the value-chain (Camlin et al., 2013). In addition to its consideration in micro-economic terms, sex-for-fish should be considered in the context of resource access (Fiorella et al., 2015). Transactional sex is common in other fishing communities around Lake Victoria (e.g., Allison & Seeley, 2004; Sileo et al., 2016; Fiorella et al., 2019).

Women’s increasing need for financial autonomy to support their own food security led them to take on other jobs that were traditionally masculine. Indeed, the study area was in a period of transition, where traditional gender roles inhibited many households’ food security in a commoditised economy. This change has been observed elsewhere in Kenya (Smart, 2017; LeBlanc, 2020). Other than omena

drying and housemaid jobs that were considered effeminate by locals, women's activities recently included quarrying with soft stones and charcoal selling. Key informants noted that women's engagement in quarrying, fishing, and boat ownership has been a recent development in the last five to ten years. While boat ownership was associated with respect and wealth, it was unclear if this also applied to women boat owners. Nunan (2021) described that the fishing-dependent population around Lake Victoria is highly migratory, which has resulted in increased female engagement in economic activities compared to their traditional domestic roles. Men were also beginning to perform income-generating activities and roles that were traditionally feminine. Vegetable foraging was historically seen as women's work and men used to be ashamed to collect vegetables; however, in 2003, men began farming sukumawiki (an indigenous leafy green vegetable) for its commercial potential (Ogoye-Ndegwa & Aagaard-Hansen, 2003). This may have reduced the association of vegetable foraging and growing with effeminacy that was absent from the present study.

Yet, shifting gender roles was recent and traditional gendered expectations and constructs of women's work still excluded women from positions of economic and political power. Owino (2019) also found that men retain power within the food system despite these changing trends. Luo men generally are decision-makers for food management, including choices about selling or retaining food, and can make these decisions without consulting their wife/wives (Owino, 2019; Musyoka et al., 2023). This dynamic was also noticed in fishing households in Malawi (Manyungwa et al., 2019). Additionally, the present study found that women's activities generally produced or handled lower-value products and processes, like omena (versus fish), shore fishing (versus offshore fishing), and soft-stone making (versus bricks). Owino (2019) also observed that selling of lower-value food crops was historically considered women's work, while more valuable product sales, like cattle, were an exclusively a male activity. Generally, key informants believed that husbands and grandparents were more respected than women and children, suggesting that power is tied to both gender and age as well as money. Indeed, women's engagement in and management of table banking organisations was identified as their main strategy for achieving some economic power. Furthermore, other authors uncovered that it supported food security through cash influx (Wang & Luo, 2019) and knowledge-sharing about locally-available foods (Volpato & Ellena, 2023). Geheb et al. (2008) detailed that wives around Lake Victoria did not share financial information with their husbands as a way of retaining control over their income and ensuring that husbands continued to contribute to the household expenditures.

Possibly as a result of their economic marginalisation, women were largely absent from local positions of political power, both within the traditional and modernised governance systems. Key informants remarked that many of women's activities (e.g., omena processing, housemaid jobs, and charcoal selling) were associated with a lower status in the community. Despite that omena processing is female-dominated, omena processors had no cooperatives or representation in local fishing governance. Women's exclusion from fishing policy and governance also occurs in Uganda

(Johnson, 2017), Tanzania (Onyango, 2017), Zambia (Ragsdale et al., 2022) and Malawi (Nagoli et al., 2018). Women processors and traders' exclusion from policy and governance can lead to their marginalisation, as found in Tanzania (Moreau & Garaway et al., 2021), Namibia (Abbott et al., 2015), and Zambia (Abbott et al., 2007).

This transition – where women were increasingly generating their own income used for household expenditures – may have implications for food security. This was also true in urban Kenyan settings, where the shift from domestic to income-generating activities was related to female autonomy, bargaining power, and improved food security (Bukachi et al., 2022). Women's overall lack of economic power may inhibit food security, as men and women generally direct income towards different expenditures. Women fishers prioritised a larger portion of their catch for household consumption in Tanzania (Moreau et al., 2018; Moreau & Garaway et al., 2021), Zambia (Merten & Haller, 2008), Congo (Béné et al., 2009) and Malawi (Manyungwa et al., 2019). Additionally, households headed by women rather than men dedicated a higher portion of the household budget towards fish and food in Ghana (Ansah et al., 2020) and Mozambique (Pfeiffer et al., 2001). The Nile perch trade in Kenya failed to contribute towards food security due to women's exclusion and men's control of the profits, which were redirected into their fishing business or spent on alcohol instead of towards household expenditures (Geheb et al., 2008). In Malawi, including women in the fishing value-chain gave them increased transparency and input (although not necessarily control) over income generated from fishing activities (Manyungwa et al., 2019). As female autonomy has been linked to improved household food security, feminisation of the fish value chains (i.e., increasing the engagement and empowerment of women in the fish value chains) could have positive effects on food security (Manyungwa et al., 2019; Asadullah & Kambhampati, 2021). Furthermore, women have been identified as nutritionally vulnerable due to their lower likelihood of participating in income-generating activities due to homestead and caring responsibilities, lower social status, and questionable land-ownership rights (Adhvaryu and Beegle, 2009; Kimokoti and Hamer, 2008).

This thematic inquiry suggests that gendered differences affect food security within this community, despite improvements and more equitable access to education. Traditionally serving male heads of household first and the preferred part of the dish may have had nutritional intake consequences; however, these trends are changing and gendered nutrient intake may be reducing. Moreover, men perceived that women's food security was better than their own, as women always had access to food for provisioning the household. Intrahousehold distribution of food and perceptions of intrahousehold allocation are explored in the next chapter.

Despite these trends towards more equitable intrahousehold food distribution, traditional gender roles defining food preparation and provisioning as feminine work prevailed. Historically, households were able to sustain themselves on the male head of household's livelihood; however, with commercialisation, women were increasingly required and expected to also provide income for the

household. Because women were spending more time away from the homestead to generate income, they chose more convenient cooking methods (e.g., frying). From a western perspective, frying can “worsen” and reduce the nutritional quality of meals (e.g., through denaturing fatty acids; Chaula et al., 2019), but if faster cooking enables adequate caloric consumption and more time for income-generating activities, it might enable better food security overall. In this way, the greater requirement to participate in income-generating activities may influence nutritional intake.

Yet, women’s income-generating potential is limited by their exclusion from certain income-generating activities, particularly in the fish and omena value-chains. Overall, men controlled household expenditures and in which income-generating activities their wives could participate. Traditional direct fishing roles of women have been closed through governance changes: women used to participate in beach seine fishing but could no longer do that because it was made illegal in attempt to protect near-shore breeding areas. Beach seining, compared to illegal off-shore fishing practices, was near eradicated because beach-based activities were easier to police. How this has affected fisheries contribution to local food security is difficult to know due to a lack of historical research on littoral food security. In contrast, the omena drying processing node was highly accessible to women due to its low cost of entry; however, the omena drying business might be lower-value and higher-risk compared to other nodes within the fish value chain from which women were largely excluded and a robust value-chain analysis is warranted. In addition to omena drying, women self-organised to form table banking groups: both of these activities increased women’s financial agency within the gendered system that marginalises them. Within the last five years, four women in the study area have become boat-owners, acquiring them through inheritance. These women-owned fishing businesses are contested: traditional governance laws prohibiting women from owning land or inheritance, illustrating the ongoing conflict between national regulations and local norms. These findings evidence a dynamic, fast-changing food system: women’s opportunities for self-employment have changed and some social norms are being contested. Ultimately, women’s exclusion from higher-value nodes as well as governance positions severely limits their agency. It also potentially limits their household’s food security, as women are more likely than men to invest income in food purchasing.

Education, migration, and food security: “The young must care for the old... We must pay school fees.”

Schooling was a recurring theme throughout interviews with residents. Primary school attendance – either private or public – is mandatory in Kenya (Kenya Constitution, Article 53, 2010). Key informants felt legal pressure to pay for school fees:

The government is on your neck about school fees. (Middle-aged woman, table banking focus group)

Food insecurity and inability to pay school fees likewise challenged migrant workers in Naivasha (Volpato & Ellena, 2023). Several other authors noted the economic pressure of school fees in Western Kenya (Kakooza & Kiumuna, 2000; Ainsworth & Filmer, 2002; Ice et al., 2011). In the present study, most children also attended secondary school because formal employment of youths under eighteen was illegal (Figure 25). While children helped with agriculture, omena drying, and other work around the homestead, they generally were sent to school because they were unable to get a job and education was perceived to support their employment potential as an adult:

If I cannot pay school fees, my child sits idle at home. (Mother in an agricultural village)

Legally, children are not allowed to work in employment; however, their contribution to the local economy through homestead labour and farming activities is significant (Nyambetha et al., 2003). Many people sold cows and other investments to pay for school fees twice annually.



Figure 25: Secondary school students work on a group activity in a school building made of corrugated iron sheets. This activity was part of a failed methodological attempt to engage children youths in dietary data collection (Pounds, in prep).

The relationship between participation in fishing and education was inverse. Older male fishers expressed that during the “glory days when fish were plenty”, school was less important. Many young men would drop out of school to fish and earn good livelihoods. As fishing more recently became unreliable, education was increasingly important because education was perceived to enable formal employment opportunities (see also van der Knapp & Ligtoet, 2010). People perceived that more

education led to better income and thus empowerment through wealth. Higher education improved a person's social status, as education was highly valued in Luo ethnic culture. Formal employment with regular salaried pay also increased a person's social status and was desirable; however, few formal jobs were available, and many youths still resorted to fishing as an alternative. In contrast to formal employment, fishing was highly accessible without education. Fishing was characterised as a job for youths to do that requires little education or money to participate. For instance, one younger fisher said, "We don't go to school to learn how to fish." Families generally tried to provide their children with enough education to avoid resorting to fishing. Yet, many fishing families were dependent on fish catch for cash to pay school fees. One wife of a fisher remarked, "a poor catch means I cannot pay school fees."

Education has had implications for women's wellbeing. Increasing women's access to education in Kenya has been linked to increased empowerment and financial wealth (Omwami, 2013) and increased access to education significantly improved food security (Mutisya et al., 2015; Mutisya et al., 2016). Yet, the data from this study suggests that, along with food expenditures, school fees were financially burdensome and a major expenditure. School fees arose as a major concern and expense in all conversations with residents. Many residents reflected that their food security suffered because cash was directed to their children's education:

I must pay school fees so cannot eat what I want. (Female omena dryer)

You have to sacrifice once in a while to pay school fee. (Middle-age woman in a littoral village)

I sacrifice [food] choice for school fees. (Middle-age woman in an agricultural village)

On the other hand, children receiving food at schools reduced food burdens on families. Schools provide meals – day schools provide lunch whereas boarding schools provide three meals daily – and some women described that "school closing means I have more people to feed." Those who can afford boarding school have even less mouths to feed at home. The potential implications of legally and social-mandated schooling on local food security seems complex and requires further research.

Orphans were also commonly discussed and placed additional burdens on households by creating more mouths to feed and more school fees to pay. It was noted that feeding orphans was a particular challenge, and that this group often only ate leafy green vegetable and ugali; orphaned children may be a particularly nutritionally vulnerable group (future studies using methods from Chapter 7 should include data on whether or not the child is an orphan). Taking in orphans has elsewhere been described as a traditional part of Luo culture (Prince, 2008). The increasing number of orphans from the HIV/AIDS pandemic have forced adoption through non-traditional methods (e.g., by matriarchal

rather than patriarchal kinship) and challenge households with additional requirements for school fees and food (Nyambedha et al., 2003). Orphans can be marginalised by intra-household food allocations and receive less or poorer quality foods than biological children (Nyambedha et al., 2003).

Driven by their aspirations for their children's career and income, parents prioritised education; contradictorily, the lack of employment opportunities may negate any competitive edge that education potentially provides. The food security-related sacrifices parents feel that they make in order to pay for their children's education may not improve their children's livelihood. Comparably in Vietnam, aspirations for youths to obtain higher-salaried 'city' jobs led to a loss in agricultural knowledge that threatened food production (Punch & Sugden, 2013). Hence, youths and their families in the present study may benefit from diverting resources from secondary and higher education towards formal or informal vocational and agricultural training. This shift might better support food security through increased production potential. Furthermore, money previously spent on school fees could be used for food purchasing or business-related expenses that could improve income to more immediately improve their food security. This switch might require altering local perceptions and definitions of 'education' in light of Luo ethnic values emphasizing the importance of education.

When children became young adults ('youths'), expectations about caretaking responsibilities changed. Key informants believed youths were responsible for caring for their elders, as found elsewhere in the world (e.g., Punch, 2001). The care-taking responsibility of younger people for older people was apparent among all demographics:

Youths need employment to take care of the old. (Male Elder in a littoral village)

The old depend on the young. (Politician)

It is the duty of the young to care for the old. (Young worse-off woman in an agricultural area)

Youths give back to society. (Female elder in a littoral village)

Employed youths bring in money. (Fisheries government representative)

As Luos, that is our culture. We should take care of our parents. (Fisheries government representative)

The last quote demonstrates that this value had a strong cultural component. Definitions of success can be inherited intergenerationally globally (Worth, 2018). Younger people felt a pressure to assist the family, and both men and women were expected to "pay their fair share" (Cage farmer). Traditional intergenerational relationships built on respect and reverence of the old by the young – traditionally thematic across Africa – might be changing as North/Western-centric values of

individualism and capitalism are adopted (Muia et al., 2013); however, this change was not apparent in this study area.

Yet, the ability of family members to contribute to the household income was highly dependent on their health status. The population's vulnerability to diseases were cited, particularly HIV/AIDs, arthritis, and diabetes, with respondents noting that food insecurity compounds these disease problems. Cholera and other water-borne diseases were of concern to everyone, although older people were particularly vulnerable to these outbreaks. Youths attributed cholera and water-borne diseases to poor hygiene and recommended improved waste management systems to reduce the disease risks. Due to the ongoing exposure to these diseases, older people became too frail to fish – key informants related this to the HIV epidemic and poor diets. Indeed, the fisheries value-chains were dominated by younger able-bodied people. Food insecurity may have a greater impact on the elderly: Older people often require more nutrient-dense diets to remain productive (Pillsbury et al., 2010). In this study, older men and women lacked the strength and physicality required for handling nets on boats and carrying basins of omena. Some older women practiced 'omena picking', where they would collect any remaining omena off beaches or fields to sell on. Others turned to crop farming, managing their own plots.

Old people who fish are desperate. Old people who stay home have children to look after them. (Politician)

The pressure on younger people to provide for elders, coupled with food commoditisation and concomitant desire for formal employment, changed food habits and preferences. Food preferences were shifting towards convenience and lower-cost formats. For instance, younger people preferred fried foods that were faster to cook and required less fuel, whereas older people preferred boiled foods that required longer cooking times, as in Tanzania (Moreau & Garaway, 2021). Younger people preferred convenience foods because they required more time spent on income-generating activities as a result of food commoditisation. Other authors found that lower fuel requirements, more efficient cooking times, and reduced smoke were desirable attributes of innovative cooking technologies among Luos in western Kenya (Person et al., 2012). Another example is that households used to ferment vegetables with milk to soften them (Ogoye-Ndegwa & Aagaard-Hansen, 2003). The present study found that households still also add baking soda or soda ash (a mixture of sodium carbonate and salt). They did not mention fermentation, which may be another cooking method abandoned due to time constraints.

The need to generate cash for food purchasing meant that younger people spent large swaths of time away from the homestead, increasing household labour demands on elders. This meant that the old were still taking care of the young in many ways. While their adult children participated in income-generating activities away from the homestead, elders remained in the homestead, providing agricultural labour and childcare for their grandchildren (see also: Muia et al., 2013). Owino (2019)

added that older family members were responsible for land cultivation. While grandparenting is viewed positively, this new role places additional burdens on grandparents (Muia et al., 2013), a phenomenon that is an international issue (Grünwald et al., 2022). Furthermore, decreased engagement and bonding between parents and their children from intergenerational space may limit intergenerational relationships (Muia et al., 2013; Vanderbeck & Worth, 2015).

Some younger men and their families migrated to Sindo for employment (mainly fishing and some for aquaculture) to supply remittances. In contrast to a diaspora, key informants agreed that people still generally migrated into the study area, still driven by employment opportunities in fisheries, farming, and more recently, fish farming (see also van der Knapp and Ligtoet, 2010, although more recent migration statistics and studies are lacking). This migration pattern was also found in a fishing village in Uganda (Beuving, 2010) and Congo (Béné et al., 2009). Women particularly migrate into the area upon marriage; traditionally, Luo men seek wives from outside their community. Schoumaker et al. (2013) also recognised that Africans generally migrate for family, work, or study obligations, mostly to other areas in Africa. Flahaux & De Hass (2016) claim that African migration is not driven by poverty but rather by processes of development and social transformation that have increased peoples' migratory capabilities and aspirations. Rather than migration being a reaction to poverty, emigration is enabled by affluence (Flahaux & De Hass, 2016). When poor people migrate, it tends to be over smaller distances (Flahaux & De Hass, 2016). Key informants lamented that employment opportunities were lacking generally, and youths relied on staying near the homestead rather than migrating in response to financial hardships. Many elders in the present study reported that their children's employment in urban centres was insufficient to cover their expenses, let alone send remittances:

If you leave, you will come back... there's no money to sustain yourself in Kisumu or Nairobi. (Middle-aged woman)

Owino (2019) also noted that migration to urban centres in Kenya increased expenses. Because of this, elders in the present study often sent food to their adult children, as a 'reverse remittance' (Figure 26). The 'Millennial' generation's difficulty finding employment and continued reliance on their parents as a privilege is a global phenomenon (Worth, 2017). Another study in Western Kenya (Lugari District, not on the shores of the lake) quantified that almost 40% of rural households send maize to their relatives in urban areas, creating additional food insecurity for sending households (Djurfeldt & Wambugu, 2011). This effect is generally pronounced for the poor (Anderson Djurfeldt, 2015). That study also calculated that these households transferring maize in kind had significantly lower maize intake than the national average. Furthermore, migration for work to Naivasha reduced consumption of nutrient-rich indigenous vegetables and increase consumption of convenience foods (Volpato & Ellena, 2023). In contrast, for poor households on the shores of Lake Nakuru, multi-spatial livelihoods (i.e., households with livelihoods in both urban and rural areas) were linked to

improved food security (Foeken & Owuor, 2001). The present study did not compare food security between households with single and multi-spatial livelihoods and more research is required.



Figure 26: Jennifer, one of the six elder key informants who participated in the Oral Histories activity, and her millet crop. When not harvesting, she carries her nets to Wadiang’a beach (approximately a 45-minute walk) to do her omena-drying business.

Within households, key informants identified elders as a nutritionally vulnerable group, particularly those whose children worked away from the homestead. In contrast, other studies found that caretaking could improve nutritional status for elder women (Ice et al., 2011). This may be contingent on socio-economic status: wealthier elders were perceived as more food secure than those from worse-off families. Socio-economic status was also positively correlated with anthropogenic measures among the elderly in western Kenya (Ice et al., 2011). Other authors also described that elders in Sub-Saharan Africa are a nutritionally vulnerable group: scholars estimate that over half are underweight and a quarter are overweight, where high rates of HIV/AIDS and poverty exacerbate their vulnerability (Kimokoti & Hamer, 2008).

In summary, pressure to pay school fees burdened households and restricted subjective experiences of food security. It also restricted food purchasing and might be affecting nutritional intake, which requires more research. The pressure to pay school fees was imposed by a combination of government regulations, ethnic values, and aspirations. Yet, their aspirations for a ‘better’ livelihood for their children were unattainable because livelihoods for youths were limited: local employment

opportunities were lacking and urban jobs were insufficiently paid to cover costs of living, let alone allow for remittances. Thus, youths often remained at home, waiting to find local work. In desperate situations, young men resorted to fishing and young women resorted to omena drying; however, young people did not aspire to become part of the fish or omena value-chains due to their unpredictability and shaming associations with poverty & debauchery. The fish and omena value-chains no longer attract youths.

Traditional values encouraging young people to take care of elders has been threatened by youths' limited job opportunities and a commercialised economy. Elders remained at the homestead, carrying agricultural and childcare responsibilities while younger people searched for paid work, critical for food purchasing. As a result, elders carried significant labour burdens. Furthermore, households were switching to more convenient cooking methods (frying) to minimise time spent cooking, which may have nutritional implications. Prioritising first education then off-homestead employment had negative consequences for food security.

6.2.2 WEAI

The enumerators obtained data from 167 households. WEIA scores were calculated for all 167 households (Table 7). The average WEIA score was 0.853 and only 4.8% (n=8 of 167) of women reported that they did not make any decisions whatsoever. WEIA scores above 0.8 are generally considered “good” in that the women have a high level of empowerment (IFPRI, 2012). The WEIA was not correlated with MDD-S nor HDDS. Women's average time spent on work is shown in Figure 27. More time was spent on domestic work and cooking, but no major differences in time spent on various activities were apparent.

Table 7: Percent of women with at least some degree of decision-making input in each income category followed by the percent of women with ownership or joint ownership of each asset type.

WEAI category	Activity	Percent of households engaged in that category	Percent of women with input into decisions regarding each activity
Decision-making	Subsistence farming	46.7% (n=78 of 167)	79.5% (n=62 of 78)
	Cash crop farming	26.9% (n=45 of 167)	77.8% (n=35 of 45)
	Livestock raising	40.7% (n=68 of 167)	52.9% (n=36 of 68)
	Non-farm activities	40.7% (n=68 of 167)	94.1% (n=64 of 68)
	Wage & salary employment	35.9% (n=60 of 167)	96.7% (n=58 of 60)
	Fishing	12.6% (n=21 of 167)	100% (n=21 of 21)
	Fish trading/processing	41.3% (n=69 of 167)	100% (n=69 of 69)
Asset		Percent of women with ownership or joint ownership of asset	
Ownership of Asset	Agricultural land	22.8% (n=38 of 167)	
	Large livestock	16.8% (n=28 of 167)	
	Small livestock	30.5% (n=51 of 167)	
	Poultry (chicken, turkey, duck)	44.3% (n=74 of 167)	
	Fish pond or fishing equipment	3.59% (n=6 of 167)	
	Farm equipment (non-mechanized)	5.39% (n=9 of 167)	
	Farm equipment (mechanized)	2.99% (n=5 of 167)	
	Non-farm business equipment	3.59% (n=6 of 167)	
	The house (or other structures)	53.3% (n=89 of 167)	
	Large consumer durables	49.1% (n=82 of 167)	
	Small consumer durables	85.0% (n=142 of 167)	
	Cell phone	82.0% (n=137 of 167)	
	Non-agricultural land	11.4% (n=19 of 167)	
	Means of transportation	7.78% (n=13 of 167)	
Activity		Percent of women with input into how the income from each activity is used	
Control over use of income	Subsistence farming	55.1% (n=43 of 78)	
	Cash crop farming	5.11% (n=23 of 45)	
	Livestock raising	32.4% (n=22 of 68)	
	Non-farm activities	88.2% (n=60 of 68)	
	Fishing	47.6% (n=10 of 21)	
	Fish trading/processing	97.1% (n=67 of 69)	
	Major household expenditures	73.3% (n=74 of 101)	
	Minor household expenditures	80.7% (n=117 of 145)	
Activity		Percent of women with input into how the income from each activity is used	
Access to and decision on credit	Credit from an NGO	1.80% (n=3 of 167)	
	Credit from a formal lender	19.8% (n=33 of 167)	
	Credit from an informal lender	18.6% (n=31 of 167)	
	Credit from friends/family	47.3% (n=79 of 167)	
	Credit from an MFI	8.98% (n=15 of 167)	
	Credit from an informal group	42.5% (n=71 of 167)	

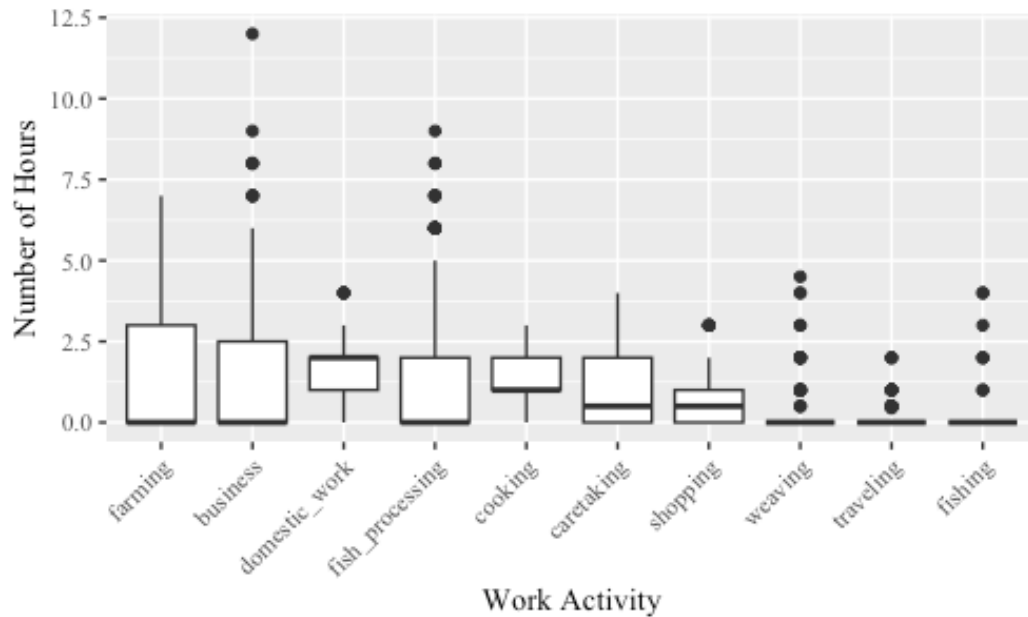


Figure 27: The average number of hours per day women spent on various work activities.

6.3 Discussion

People in this study area were perhaps over reliant on fisheries resources for their livelihoods, creating potential risks for their already precarious food security. Fishing business consolidation (described in Chapter 4) may put fisher livelihoods at risk, as they have fewer alternative sources of capital at their disposal in times of crisis. Furthermore, integrated businesses tended to aggregate and export fish from the study area, such that fish mainly contributed indirectly to food security through income generation. The role of resources and food security will be quantified in the subsequent chapter.

This population was on the precipice of a livelihood transition: while still dependent on fishery livelihoods that are increasingly unreliable, people were beginning to look and aspire to other industries. Historically, people migrated to Sindo seeking employment and riches from fisheries, resulting in a population boom. This population boom led to increased pressure on fisheries, decreased biodiversity, and decreased catch-per-unit-effort. Fishing became less profitable, and the local availability of fish decreased. Continued fisher migration around the lake (following Nile perch movements) had social consequences for littoral communities (Nunan, 2010; Nunan et al., 2018). Despite direct inquiries about migration, key informants in this study did not highlight it as an issue – they alluded that migration around the lake had decreased or even ceased. They asserted that migration into Sindo and its surrounding areas for fishing was the main type of migration occurring, and very few migrated out of Sindo (i.e., to inland villages or urban centres). Decreased migration into Sindo may be a result of the declining Nile perch trade and increasing reliance on tilapia and omena that have lower profit margins and thus lower incentives for inward migration, although this requires more in-depth research.

Meanwhile, other food became increasingly commoditised, echoing global trends and having nutritional, social equity, and ecological externalities (Dewey, 1989). **In the absence of strong local agricultural production, this large population with decreasing income from the Nile perch fishery and a lack of agricultural production was faced with a decreasing ability to access food.** With the Nile perch industry development, littoral populations abandoned or reduced their investments in subsistence and cash crop agricultural development to take advantage of the Nile perch economy (Pringle, 2005b; Beuving, 2015; Mwakubo et al., 2007). The move to fishing – like the intensification of tobacco production in Zimbabwe – redirect time and energy resource away from food crops, with positive effects on income (Rubhara et al., 2020). When the Nile perch industry declined, income for food purchasing became less available and cash crops were provided insufficient alternative income and food availability. Food purchasing is a critical food security strategy for the rural poor but limited by insufficient income-earning opportunities (Pereira et al., 2014). **In the absence of the lucrative Nile perch trade, some households have turned to the omena fishery,** less valuable but an affordable food source (its nutritional value will be illuminated in the next chapter).

Because commoditisation strengthened associations between income and respect, fishers lost social status and became associated with “debauchery”, i.e., alcoholism and sex work (the theme of respect will be explored further in Chapter 8). With the decreasing potential and respectability of the fishing industry, fishing became a fall-back rather than an aspirational profession (Allison & Ellis, 2001). Instead, parents aspired to provide their children with education. Yet, **schooling was a major financial burden** that might negatively affect food security by diverting cash towards schools and away from food purchasing, and this hypothesis requires evidencing. In this study, secondary education, which is subsidised in Kenya, was used to occupy youths in the absence of work or vocational training opportunities (Ohba, 2011). While youths helped with household tasks and agricultural work, they were banned from employment (GoK, 2019). Thus, they were sent to schools to occupy them with aspirations that it would enable future livelihoods in paid work (Punch & Sugden, 2013). Yet, these **aspirations did not translate into improved employment, as opportunities were limited.** Few migrated to urban centres where more respected (i.e., salaried) jobs were available due to the higher living costs. Those who did were unable to provide remittances, instead relying on food sent from their parents who remained at home. Thus, this **urban migration threatened food security for both the young adults and their family left behind.** Furthermore, it placed additional burdens on elders, who were left responsible for homestead agriculture and childcare (see also: Muia et al., 2013). This dynamic contradicted with local values where the young were expected to provide for the old, but were unable due to the commoditisation of the food system coupled with the lack of employment opportunities. Elders may be a particularly nutritionally vulnerable group; however, this was not investigated in the quantitative studies of this thesis and requires future research.

Despite the increased need for income for food provisioning and more equitable access to education, **gender inequalities had persisted** and were preventing women from generating income. Whereas women historically relied on their husbands for income-generation, the commoditisation of food has driven them off the homestead to search for income-generating activities. Although progress is being made towards women's empowerment, as evidenced through their transition into income-generating activities and improved access to education, inequalities have persisted. Women's improved access to education alone does not appear to have resulted in improved food security due to ongoing inequalities in income-generation. In particular, gendered livelihood differences limited women's ability to generate income. **While the community continued to rely on fisheries for economic activity and women played an important role in omena processing, this position was high risk and low reward** (described in Chapter 4). Fisheries productivity reduction increased their vulnerability through decreased availability of raw product. Women lacked opportunity in other, more lucrative nodes of the omena value chain. Within the Nile perch and Nile tilapia value-chains, women were limited to trading for bandas, another high risk and low reward node. The only position available to women that seemed lucrative were 'Mama Samaki' fish vendors, which were underrepresented in my sample group and their business and livelihoods warrant additional research. Women's absence from higher-value activities is also seen in Uganda and Malawi (Njuki et al., 2011). Additionally, **women in the present study lacked institutional support, were omitted from leadership positions, and lacked ownership and decision-making power within the household.**

The more economic resources women produce and control, the lower is the level of gender stratification... males tend to be more dominant at higher levels, which discounts the amount of power women receive based on their economic resources.
(Chafetz, 2006).

Gendered land ownership rights may have consequences for women's food security. As also established by Olale & Henson (2013), wealth was tied to land, but only men have access to land. The impact of gendered land ownership rights in the present study on women omena processors was that they lacked direct access to land as a wealth resource (the implication on food security is quantified in the next chapter). This discussion aligns with the WEAI results, reflecting women's low asset ownership and access to credit, found globally (Pyle, 2006). Lack of access to land created additional costs for them as they were forced to rent land or were delegated to poor-quality land for drying their omena. The costs and terms of these arrangements requires additional research. Considering the correlation between almost exclusively male-owned land and food security, women's food security may be contingent on their relationships with men. This reliance has consequences for women's rights, where women may choose to stay in abusive relationships for food security – as quoted regarding sex-for-fish relationships, women feel “we have no choice”.

These gendered inequalities had negative consequences for food security. Restricted opportunities for income-generating activities limits women's income-earning potential. This is a significant lost opportunity because women may direct more resources towards supporting household food security (to be explored in the next chapter). Women's absence from many nodes of the fish value-chain (e.g., boat ownership, aggregation, local governance) and their lack of decision-making input into household decisions regarding expenditures may be the reason that economic benefits from fisheries fail to translate into improved food security and wellbeing. As evidenced in the next chapter, omena dryers, who are mainly women, retain a portion of the product for household consumption; fishers, who are mainly men, do not generally retain fish catch for household consumption (see also Pfeiffer et al., 2001; Merten & Haller, 2008; Béné et al., 2009; Moreau & Garaway, 2018; Ansah et al., 2020). While women have input into the use of household resources, they lack decision-making power regarding income, whether fish are sold or consumed at home (and in which home, if in a polygamous household), asset ownership, and access to formal credit. Furthermore, they lack decision-making power regarding whether fish is sold or consumed at home. They managed to scrape together some 'thin' agency (Klocker, 2007) through table banking and omena drying, both of which were feminised activities. **Women relied on omena drying as an accessible income-generating activity.** Yet, omena was not valuable enough to trade for equally (financially nor nutritiously) valuable food. Instead, cash income from omena sales was used to purchase maize and pay for other household expenses. The omena-drying business also directly supported household food security because, unlike fish, omena was retained for household consumption. Insufficient primary data was collected from fishers to establish their expenditures from fishing income, but literature suggest that they prioritise reinvesting into their fishing or other businesses, or spending it on leisure activities (Beuving, 2010; Sileo et al., 2016).

Gender inclusion in fisheries and other higher-value economic activities would likely support improved food security. While increasing women's access to fish may not improve their income as fisheries catch falls (Fiorella et al., 2015), it may increase gender equity within the fishery value-chain and the portion of catch that is directed to the homestead. **The present study shows that women were beginning to exert agency, as evidenced by the table banking groups and new female boat owners.** This may be a result of increased need for generating household income, leading to increased work pressure on women (Gironde et al., 2021). Improving women's agency and engagement in income-generation would likely result in food security improvements. Supporting women's empowerment – particularly their ability to acquire assets and engage in entrepreneurship – might result in higher household incomes that are directed towards supporting household food security. Possible interventions might consider improving women's access to credit, women's capacity building, and omena-drying cooperatives. Access to credit and membership to social groups have been underlined as critical to income diversification for fishers in this area (Olale & Henson, 2012). Improving omena's quality and thus, value, would support omena-dryers and improve access to affordable animal source food. Simple adaptations could include uplifting nets onto tables and

providing transparent covers to decrease contamination and product destruction. Collective action (e.g., cooperatives) could be organised utilising table banking groups to support innovation, technology, and rally for representation in local fisheries governance. Women's groups could enable omena processors to increase the value of omena by, for instance, collective action enabling investment into technology and marketing. Technology and developing value-chains for agricultural items, for example, dried Mango from Vietnam, promotes and encourage local products to be more hygienic, retain their nutrition, and support local livelihoods (Truong & Sidique, 2022; Van Le & Van Luan, 2023). Smoothing omena dryers' income across the month may mitigate their financial risks, using storage strategies to smooth price volatility. For instance, omena dryers could sell to a co-operative that replaced the aggregating function of the traders (although careful consideration of power dynamics between omena dryers and traders may be critical to avoid conflicts, and strong national and traditional governance support of the co-operative). Currently, omena dryers are invisible women: the omena fishery is underrepresented in policy and governance overall (Aura et al., 2022), but this present research highlights the specific need for gender inclusive approaches.

Chapter 7. The nutritional role of fish and state of food security among Kenyan communities on Lake Victoria's shoreline village Sindo

This chapter aimed to characterise diets of a littoral Kenyan community on the shore of Lake Victoria, identify the nutritional sufficiency of those diets, and understand those diets in the context of the households' resources. The research questions were:

- Through what pathways are people from different socio-economic groups accessing fish, and what are their barriers to fish consumption?
- How does the nutrient contribution of fish compare to other commonly consumed foods? To what extent are fish a source of nutrients, and does that vary between socio-economic class or generation? What other barriers to nutrition security do they face?
- What nutrients are being supplied through commonly consumed fish? What role do fish from fisheries and aquaculture play in the provisioning nutrients? Are cultured fish a substitution for, or supplement to wild caught fish, and how does that impact on nutrient intake?

7.1 Methods

The quantitative methods involved a household questionnaire and dinner intake measurements. Nutrient intake was estimated by measures of nutrient intake for the main (evening) meal complemented by recall of the previous 24 hr intake obtained from the household questionnaire.

7.1.1 Interhousehold questionnaires

The interhousehold questionnaire (Appendix 3) aimed to understand diets in the context of the households' resources. Key informants agreed with the following definition of a household "everyone who sleeps under the same roof and eats from the same pot" (Geheb et al., 2008). Thus, this survey aimed to collect data from the male or female head of household about household's diets, livelihoods, and access to a variety of resources. Analysis compared outcomes at the household level to understand differences between demographics.

Survey Tool Design

The interhousehold questionnaire included six sections: demographic details, 24-hour recalls, household capital, and Food Insecurity Experience Scale (FIES).

Demographic details

This initial section asked respondents about each of their household members, their gender, age, education level, and main occupation, how often they ate different animal source foods (ASF).

24-Hour Dietary Recalls

The questionnaire included individual 24-hour dietary recalls, as explained in section 6.1.

Household capital

This questionnaire also included questions about household capital. Specific household resources were measured as indicators for each of the capital types as described by the Sustainable Livelihoods Framework (Chambers & Conway, 1992; DFID, 1999; Elizondo et al., 2017), which has been used elsewhere in fisheries social science research (e.g., Nunan, 2010). Capital indicators of wealth are context-specific and thus must be defined for each study area (i.e., we cannot use the same indicators across different regions, although some may overlap). Potential indicators of each type of capital were identified during the informant interviews by specifically asking respondents to describe differences between the wealthier people and poorer people in their community. We asked participants “How do you tell the difference between rich and poor people in Sindo?” and “What human/social/environmental/physical/financial resources exist, and what types of people do or do not have access to them?”. The resulting indicators are listed and categorised in Table 8.

Table 8: The indicators used to assess each of the types of capital as described by the Sustainable Livelihoods Framework.

Capital	Indicators
Human	The number of family members (including number of dependents); the family members’ income-generating abilities.
Social	Social group membership (e.g., religious groups, informal savings groups, women’s groups, professional associations).
Environmental	Household foraging habits; land owned; land rented; number & purpose of crops; source of water
Physical (assets)	Ownership of physical assets (e.g., electronics and vehicles); type of cooking fuel and electricity; housing type; (number of boats was originally examined in the physical wealth index PCA, but was indeterminate of wealth status)
Financial	Monetary savings (measured by the length of time that the household could live off of their savings); ability to pay for hairdresser; type of schooling;

Food Insecurity Experience Scale (FIES; FAO, 2018)

The FIES is a standardised series of questions used to quantify household or individual subjective experiences of food security and is useful to examine links between different sectorial perspectives,

such as nutrition and agriculture (Ballard et al., 2013). The indicator of perceived food insecurity was originally developed in response to an imbalance of literature concerning food availability compared to accessibility; instead, it framed food security as a “lived experience” (Saint Ville et al., 2019). In contrast to the 24-hour recalls, FIES is used to measure the behavioural and psychological effects of food insecurity (Onyenekwe et al., 2022). The FIES has been used previously to examine food security and food value-chains elsewhere in Kenya (Mwangi et al., 2020; Kansiime et al., 2021). The complete list of questions is presented in Appendix 3, questions 34 through 43. The questions are used to generate a summed score: any ‘yes’ answers are given a value of one, and ‘no’ answers are given a value of zero (Ballard et al., 2013). The values are summed to generate a total score for each household, where higher scores indicate more food insecurity experiences, and lower scores indicate more food security experiences.

The FIES was carefully chosen from a list of several tools used to measure food insecurity experiences. For this study, the FIES was used instead of the ‘Household Food Insecurity Access Scale’ (HFIAS; Coates et al., 2007) for practical reasons (time and resource limitations): the FIES was designed for cross-country and cross-sociocultural use, whereas the HFIAS would have required modification and validation at the population level (Coates et al., 2007; Ballard et al., 2013). Furthermore, the FIES is shorter than the HFIAS, and we aimed to keep the survey as short as possible to respect the participants’ time. While the ‘Household Hunger Scale’ (HHS) is also designed for cross-sociocultural use (Ballard et al., 2011) and has been used in the study area (Waswa et al., 2021), it focuses on identifying extreme food insecurity (Ballard et al., 2011) and may provide less nuance across the food security spectrum than the FIES. As I aimed to target both food secure and food insecure households, the FIES was more appropriate for my study.

Data collection

Data were collected between January through April 2023 using a mobile application designed for remote data collection (Lakshminarasimhappa, 2022). The enumeration team aimed to collect at least 300 data points, which was recommended as the minimum when using the FIES (IT, FAO 2018). Enumerators were trained: one of them translated the survey into Swahili and Duluo, then the other translated the Swahili and Duluo translations back into English. Then we compared the two English versions to identify any discrepancies in translations. Enumerators then conducted the survey with each other, then with two friends in English and under my supervision, correcting and discussing issues and approaches along the way.

Trained enumerators collected data from people in Sindo, Wadiang’a (the main fish landing site next to Sindo), Roo, Rowo, Masaré, Mbita, Nyakwara, and Ragwe. The enumerators stationed themselves on the main roads or on the beaches, randomly asking every third passerby if they would be willing to participate. Inclusion criteria were: the potential respondent was at least 18 years old, they were the head of household, they lived in the study area, and they were willing to participate. If the

participants met the inclusion criteria, they were provided information about the project and asked to sign the consent form prior to the interview.

Statistical Analysis

Prior to statistical analysis, data were cleaned and organised using Rstudio (R Core Team, 2020). This section describes the subsequent data analysis for each hypothesis.

The nutritional dietary diversity score (MDD-S) and the economic dietary diversity score (HDDS) were calculated as described in 6.1. The ‘perceived food insecurity experience’ (‘Food Insecurity Experience Scale’ or FIES) was calculated by summing the total number of “yes” answers to the FIES questions. Thus, a higher score represented a higher degree of food insecurity, whereas a lower score represented a higher degree of food security.

Physical wealth index

While human, social, environmental, and financial capital indicators were succinct (i.e., 1-3 variables each), the list of physical capital assets was long and I was concerned that including them individually in the linear regression models would cause the model to be too complicated (as interactions between each of the variables within each capital type would be examined, including more than 3 would generate multiple interaction effects that would be too numerous for the model to function). The physical wealth index was used as a composite indicator of physical capital. Based on the physical asset indicators, a physical wealth index questionnaire was designed, explicitly asking participants about each of the indicators. For example, the wealth questionnaire included questions like “Do you own a car?”, and “What material is your roof?” (all physical wealth index questions are presented in Appendix 3, questions 2 through 26). A physical wealth index rather than a financial-based metric alone (e.g., living income, see: <https://align-tool.com/source-map/kenya>) was used because the study area’s economy was in transition though largely still based on a variety of capital types and not only cash and income.

We then wanted to verify that the physical wealth index questionnaire and physical wealth index calculations method accurately representing the perspectives of the community on which families were considered better or worse off. So, this questionnaire was conducted with four known better-off, four worse-off, and four medium households in Sindo (these respondents were identified by local key informants, by asking them to please identify specific people who they perceived as better-off, worse-off, and in between). We plotted their responses using a Principal Component Analysis (PCA), which indeed showed that answers indicating poverty and wealth were divided by the two main dimensions in the PCA plot. Figure 28 shows that these indicators explain the majority (>63%) of the variance. For example, the number of cows owned by the household is strongly associated with dimension 1 (about 0.85), strongly driving where a household is positioned along dimension 1. As the ownership of assets listed by the respondents matched with the eigenvalues of known better and

worse off families on the PCA, this verified that using the eigenvalues as a numerical index was accurately representing the perspectives of the community on which families were considered better or worse off when considering assets.

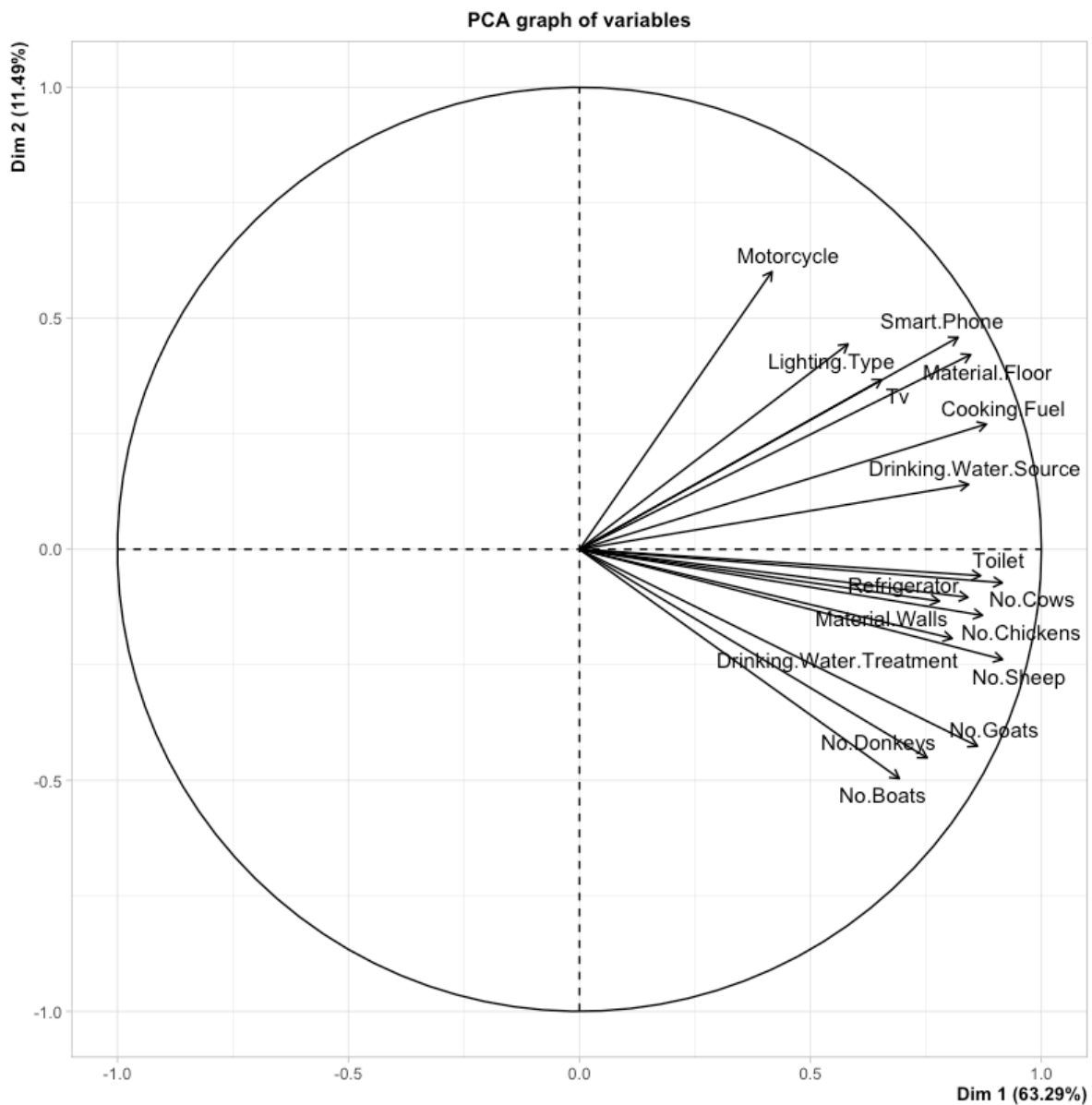


Figure 28: PCA results showing that the indicators explain over 63% of the variance between participants with only one dimension.

For the main survey, the same physical wealth index questionnaire responses were put into a PCA, and eigenvalues resulting from the PCA were used as the index. In this way, the physical wealth index questionnaire answers were transformed into a quantitative physical wealth index.

Household resources: Assessing the relationship between food security indicators and household resources

What household resources were associated with food security?

I used stepwise regression to compare the independent variables as indicators of household resources (fraction of adults with income, fraction of children, social group membership, savings, table banking group membership, physical wealth index, participation in foraging, land ownership, land rental, crop farming, and participating in fishing or the omena business) against the dependent variables, which indicated food security (food insecurity experience 'FIES', nutritional dietary diversity 'MDD-S', economic dietary diversity 'HDDS', and satisfaction with fish and omena consumption⁶). The regression models considered interactions between household resources that represented similar capital types (e.g., both fraction of adults with income and social group membership were forms of social capital and thus their interaction was tested). The results of the stepwise regression for FIES, MDD-W, and HDDS are displayed in a table.

To visualise the relationships between the numerical variables (fraction of adults and children in the household, participation in fishing or the omena business, physical wealth index, savings, size of land rented or owned, number of crops grown, distance to land, HDDS, MDD-S, and FIES), a Pearson correlation matrix was computed. Statistical significance for each correlation coefficient was assessed using pairwise correlation tests, and a significance matrix (p-values) was generated.

What household resources affect what animal source foods a household ate yesterday?

A linear regression model was used to compare all the household resource variables against the type of animal source food consumed. For each significant correlation, a Tukey test was used to compare the independent variables against the type of animal source food consumed. The results of the Tukey test were visualised on a boxplot.

Linear models were used to examine whether participating in the fishing or omena businesses was correlated with the likelihood of eating each animal source food eaten yesterday and visualised in odds ratio plots.

What factors are associated with fish consumption satisfaction?

To visualise the relationship between all the independent variables (listed above) against the dependent variable "satisfaction with fish and omena consumption", coefficients from stepwise regressions were used to produce odds ratio plots to examine the effect of the household resources on each dependent variable.

⁶ In the key informant interviews, key informants did not consider omena as a fish. Rather, only Nile perch, tilapia, and larger species were referred to as 'fish'. Thus, this thesis conserves their definition and uses the terms 'omena' for small pelagic fish and 'fish' to reference Nile perch, tilapia, and other larger species.

Dietary patterns: Identifying dietary patterns and assessing their relationship to different food security indicators

What foods are complimentary to or substitutes for fishes?

In order to explore dietary patterns and understand what types of foods were a substitute or compliment to fishes, 24-hour recall data were analysed using PCA analysis, replicating methods by Auma et al., (2019) and Galbete et al., (2017). This involved several steps in processing the data and analysis. Foods reported on a 24-hour recall at the household level were categorised into 24 common ‘dishes’, which were manually assigned based on dietary food groups (e.g., red meat vs fish), whether locally grown or imported (e.g., indigenous greens vs cabbage), and how the dishes were prepared (e.g., baked breads vs fried breads). For example, the ‘cabbage dish’ refers to sauteed cabbage, which was mostly prepared with oil, onion and tomato. The cabbage dish was differentiated from ‘indigenous greens dish’ despite also being prepared with oil, onion, and tomato because indigenous greens are grown locally whereas cabbage is imported.

Often, PCA is used to find groupings of datapoints within a dataset. In this thesis, I use PCA to identify (1) how an array of physical assets differs between better and worse off people in the community, and (2) different dietary patterns between groups of people or factors. The PCA does this by creating ‘dimensions’, which represent delineations between groups of people or factors in the PCA analysis. It creates multiple dimensions and each dimension describes a certain portion of the variance in the data. Result that rely on more than two dimensions to explain the majority of the variance is impossible to visualise on a commonly used PCA ‘circle’ graph (as used to show the results of the physical wealth index PCA); however, sometimes 3 or more dimensions are required to appropriately account for the majority of the variance (as found in the dietary pattern results below).

After categories were assigned to each food, the PCA was established using the top 20 most commonly consumed foods. PCAs are used to identify contrary, either/or type categories. This allows the researcher to analyse and characterise different groups of people in novel ways. In this analysis, the PCA identified several dimensions (components) within the food data to distinguish different types of diets within the study population. The PCA resulted in twenty components, a scree plot’s inflection point was used to identify possible components to retain. The best components to retain are those that explain the most variance in the data. The position of the scree plot’s inflection point established that the first four components should be retained, which explained 31% of the variance.

To understand which foods characterised each component, PCA-calculated eigenvalues were saved. Each component identifies two types of dietary patterns: one positively associated with component one and a second negatively associated with component one. The eigenvalues represented how strongly that food was correlated with that component. Thus, for each component, positive eigenvalues were associated with one diet and negative eigenvalues were associated with the second diet. Dishes with eigenvalues ≥ 0.2 or ≤ -0.2 were considered included or excluded from the dietary

pattern so that only the foods most strongly associated with each diet were included (Auma et al., 2019).

Do households with different resources eat different diets?

Then, I assessed whether a particular dietary pattern was associated with household resources (fraction of adults with income, fraction of children, social group membership, savings, table banking group membership, physical wealth index, participation in foraging, land ownership, land rental, crop farming, and participating in fishing or the omena business) or food security indicators (food insecurity experience ‘FIES’, nutritional dietary diversity ‘MDD-S’, and economic dietary diversity ‘HDDS’) using stepwise linear regression. To do this, coordinates for the first four⁷ components were saved into the original data frame, so that each survey included unique coordinates related to each component, explaining where that household’s diet sat along each dimension (i.e., how strongly that household’s diet “fitted” within that dietary pattern). Then similar to methods in examining correlations between household resources and food security indicators, I used stepwise linear regression to examine correlations between the dietary patterns and the variables. Separate models were used for each of the four components against the household resource and the food security indicators (eight models total).

7.1.2 Dinner intake measurements

The ‘dinner intake’ dataset was collected to calculate the nutrient intake from food consumption at the individual level. Its analysis aimed to compare nutrient intake between better and worse-off households and between family members (both generations and gender). Due to resource limitations⁸ that prevented 24-hour dietary data, dinners (i.e., the evening meal) were recorded only. Of all meals, dinnertime was selected because informants identified dinner as the main meal and the only meal that households regularly ate together at the same time, which would facilitate data collection. Data was collected by observing the family’s preparation and consumption of food, analysing the food, and calculating the micronutrient intake.

The examined nutrients were energy, carbohydrate, protein, fats, zinc, iron, calcium, Vitamin A and Vitamin B12 using the three guidelines by Zamborain-Mason et al., (2023), designed to guide researchers when identifying which nutrients to examine in any given study area. Firstly, these nutrients are essential for humans (Zamborain-Mason et al., 2023). Secondly, these nutrients are identified as commonly deficient in Kenya (Bwibo & Neumann, 2003; Cheserek et al., 2012; Harika et al., 2017). Zamborain-Mason et al., third guideline suggests, “for a given nutrient required by the

⁷ Four, because the top four were required to explain over 30% of the variance, which is the common target in this type of analysis - see also Auma et al., (2019) and Galbete et al., (2017).

⁸ It was unfeasible to follow individuals around for 24 hours monitoring and measuring everything they ate. I tried to collect self-reported diet diaries, but the data was too poor to be useful: people were unable to estimate the quantities of food they ate.

population, are aquatic foods appropriate nutrient sources or are other accessible dietary sources in the food system more appropriate?” The authors identify iodine, Vitamin D, and Vitamin B12 as particularly rich in aquatic foods globally; however, iodine and Vitamin D were not deficient in the study area, thus only Vitamin B12 was included. While aquatic foods are not particularly rich in Vitamin A, Vitamin A was included due to the potentially low dietary inclusion of Vitamin A-rich ASF like eggs and organ meats (as identified by the qualitative work). Zamborain-Mason et al., (2023) describes aquatic foods as low in calcium; however, due to the inclusion of small fish eaten whole, the relative contribution of calcium from fish was hypothetically significant relative to other foods, and thus calcium was included. While zinc and iron did not comply with this third criteria, they were included regardless as commonly deficient nutrients in Kenya, and I wanted to know the role of fish in delivering the most needed nutrients.

Survey Method & Data Collection

The activity was scheduled *a priori* with each family, selected by snowballing methods, where the family would introduce the enumerator to another family. While this certainly creates more limitations to the results than random selection, snowballing ensured that families were within the social network of the enumerator for safety purposes (i.e., the enumerator’s safety after dark and while conducting research inside others’ houses).

The enumerator visited a household at dinnertime to record consumed foods. The enumerator sat with the female head of household and measured all ingredients for each dish that was prepared for dinner. While the dinner was cooking, the female head of household answered survey questions. Survey questions included those to calculate a physical wealth index⁹. During consumption, the enumerator weighed and recorded the serving of each dish for each person, any additional servings per person, and remaining food waste on each person’s plate. Finally, the household was asked if everyone consumed as much as they wanted, and if not, the reason. Breastfeeding children were excluded because we were unable to quantify the importance of their dinner intake relative to breastmilk. This methodology will add to the 110 studies globally that have measured fish and seafood intake at the individual level (Casey et al., 2024).

⁹ I made a mistake here, and only included the household resources questions related to physical capital, accidentally omitting those inquiring about other types of capital. However, as the correlation matrix shows that the wealth index I correlated positively to financial wealth (savings), environmental wealth (land owned), and negatively to some human wealth indicators (fraction of children and participation in the omena business), I think the results for the dinner data set analysed against physical wealth are still valuable for understanding household access to food security. In future, I recommend running a PCA on ALL wealth indicator (not just physical) to either (a) assess which indicators predict others and narrow down the number of indicators per wealth category, or (b) make one single wealth index that includes the indicators from across all the capital categories, and not just physical.

Enumerators used a data collection sheet, which included survey questions and a table to record food measurements (Appendix 5). Survey questions included the physical wealth index questions, their monthly ASF consumption, gender, ethnicity, and religion.

Statistical analysis

How often are households eating each type of animal source food?

The survey included questions that prompted the respondents to estimate how many times per month they ate each animal source food. Their responses were visualised in a boxplot.

What percentages of the recommended nutrient intake is dinner providing?

The following methods were used to calculate the nutrient density of each food dish. The nutrient composition of non-aquatic food was sourced from the literature (specifically from: FAO/Government of Kenya, 2018; USDA, 2022). Aquatic food samples (omena, fulu, Nile perch, 400g farmed tilapia, 200g farmed tilapia, and 200g wild tilapia) were collected from the study area in July 2023, freeze-dried, then transported to the Nutrition Analytical Services at the University of Stirling for analysis. In the absence of primary data, some assumptions were made. Firstly, frying oil was assumed to be a mixture of palm oil, soybean oil, and sunflower oil in equal parts (Tuei, 2023), as many respondents bought oil in unlabeled jugs or jerrycans. Secondly, nutritional information for Royco (seasonings) was limited, and zero contribution of selenium, Vitamin A, and Vitamin B12 were assumed; however, Royco's contribution to iron and iodine intake may be underestimated, as Royco has publicised that its product is biofortified with iron and iodine (Unilever, 2021).

Several calculations were used to determine the nutrient intake for each person. I considered the nutrient contribution of foods in the form of their cooked "dish" format. Considering the contribution of the raw food alone paints an inaccurate portrait of its contribution. For example, if omena is always fried, its consumption will inevitably include a high contribution of fats to the diet because it is cooked in oil. Thus considering the monotonous diet, nutrients from the "omena dish" is more relevant to understanding its contribution than the nutrients in raw, unprepared omena alone.

The nutrient composition per dish was calculated using nutrient composition values for each ingredient and multiplying them by the quantities of each ingredient added to the dish. The total nutrient composition was then divided by the total weight of the dish to get the quantity of each nutrient per gram of dish. The nutrient intake per person was then calculated by multiplying each nutrient per gram of dish by the total amount of each dish consumed per person. The nutrient intake per person was converted into percent of the recommended RNI, based on each person's age and gender. Because no RNI exist for Kenya, the methods used guidelines developed by the World Health Organization (WHO) and the Food and Agriculture Organization of the United Nations (FAO), as also done by Vila-Real et al., (2022).

Are there differences in nutrient intake between household members by gender, generation, or wealth?

To identify significant differences in nutrient intake between ‘physical wealth index’ and ‘family members’ (i.e., female adults, male adults, female children, and male children), I ran linear models and F-tests to examine each nutrient against ‘physical wealth index’ and ‘family members’. Then, for nutrients where the F-test showed significant differences between family members and/or wealth, I made a new linear model considering the combined effect of both wealth and family member and ran an eta-squared (η^2) test on that new model to understand which had a greater effect on differences in nutrient intake. The eta-squared values explain how much of the variance is explained by the variable.

What foods are contributing the most nutrients?

To identify which foods were responsible for contributing each nutrient (e.g., which foods are contributing the most protein?), I created jitter point graphs for nutrition contribution to the RNI for each of the foods (filtered for the top twenty contributors to make the graphs easier to read) and marked the average contribution of that food with a blue cross.

Chi-squared tests were used to examine whether participating in the fishing or omena businesses was correlated with the likelihood of eating fish or omena, respectively (the hypothesis that participation in fishing or the omena business would result in more likely consumption of fish or omena, respectively).

7.2 Results

7.2.1 Food security indicators

Enumerators collected 316 responses, 57 of which said their consumption in the previous 24 hours was not normal and therefore these 57 responses were excluded. Of respondents, 32% had family members that were directly engaged in the fishing value-chain. Of the household survey respondents, 30.5% (n=79 of 259) had an MDD-S (‘Minimum Dietary Diversity Score’, a nutritional dietary diversity score indicating the likelihood of a nutritionally adequate diet) above five and 72.4% (n=180 of 259) had MDD-S below five (recall that a score of 5 indicates the likelihood of a nutritionally adequate diet). Respondents with MDD-S above 5 ate mainly omena only and fish only, whereas respondents with MDD-S below 5 ate omena only or no ASF at all (Table 9). The average HDDS (‘Household Dietary Diversity Score’, an economic dietary diversity score indicating the ability of the household to afford a nutritionally adequate diet) of the overall sample was 5.75 (with a standard deviation of 1.34) and the average HDDS of households with the top 33% highest HDDS scores was 7.08.

Table 9: The percentage of respondents with MDD-W above and below five who ate each type of animal source food in the previous 24 hours.

Animal Source Food Consumed	Respondents with MDD-W <5 (n=180)	Respondents with MDD-W ≥5 (n=79)
No ASF consumed	39.4% (n=71)	7.6% (n=6)
Omena only	38.3% (n=68)	29.1% (n=23)
Fish only	10.6% (n=19)	20.3% (n=16)
Other ASF only	8.3% (n=15)	17.7% (n=14)
Eggs only	3.3% (n=6)	12.7% (n=10)
Multiple ASF	0.5% (n=1)	12.7% (n=10)

The average FIES score was 4.12 (with a standard deviation of 3.02) out of a possible 8, where higher scores represent greater experiences of food insecurity. Almost half of the participants indicated severe levels of food insecurity (Table 10).

Table 10: Percent of respondents who answered ‘yes’ to questions in the FIES based on their experience in the last twelve months (Ballard et al., 2013).

Assumed severity*	Scale items	Percent of respondents who answered ‘yes’
Mild	Felt anxiety about having enough food at any time during the previous 12 months (this time period applies to all 8 scale items)	68.3% (n=177 of 259)
	Not able to eat healthy and nutritious food because of lack of money or other resources to get food	46.7% (n=121 of 259)
	Consumed a diet based on only few kinds of foods because of lack of money or other resources to get food	58.3% (n=151 of 259)
Moderate	Did not eat breakfast, lunch or dinner [or skipped a meal] because there was not enough money or other resources to get food	55.2% (n=143 of 259)
	Ate less than they thought they should because of lack of money or other resources to get food	49.4% (n=128 of 259)
	Household ran out of food because of lack of money or other resources to get food	48.3% (n=125 of 259)
Severe	Felt hungry but didn’t eat because there was not enough money or other resources for food	49.0% (n=127 of 259)
	Went without eating for a whole day	36.6% (n=95 of 259)

Summary of key results

- Only half of respondents had enough diversity in their diet for nutritional adequacy.
- ASF were important for achieving dietary diversity.
- Almost half of respondents felt severely food insecure.

7.2.2 Household resources: Assessing the relationship between food security indicators and household resources

What household resources were associated with food security?

The results of the stepwise regressions for nutritional dietary diversity (MDD-S), economic dietary diversity (HDDS), and perceived food insecurity (FIES) are displayed in Table 11. Having savings or being part of a table banking group was significantly ($p = 0.009$) related to an increase in nutritional dietary diversity (MDD-S). Not belonging to a social group was significantly ($p = 0.005$) related to an **increase** in nutritional dietary diversity (MDD-S). However, not belonging to a social group amplified the other effects from social capital: having a larger fraction of adults with income was significantly ($p = 0.002$) related to a decrease in nutritional dietary diversity (MDD-S), with a much larger **decrease** from the combined effect of the household is not belonging to a social group ($p = 0.02$). Conversely, having a higher fraction of children was significantly ($p = 0.007$) associated with an increase in nutritional dietary diversity, with a larger **increase** in nutritional dietary diversity from the combined effect of the family not belonging to a social group ($p = 0.02$).

Having a higher fraction of children was significantly ($p = 0.046$) associated with a higher economic dietary diversity (HDDS) while participating in social groups was significantly ($p = 0.0005$) associated with a lower economic dietary diversity (HDDS).

Families with a higher fraction of children felt more food insecure: there was a significant ($p = 1.56 \times 10^{-5}$) and positive effect of the fraction of children on FIES (recall that a higher FIES indicates feeling more food insecure). However, families with a higher fraction of income-generating adults felt more food secure: significant ($p = 0.0008$) and negative effect of having a higher fraction of adults with income on FIES.

While land ownership and participation in crop farming were not significantly related to nutritional dietary diversity (MDD-S), their interaction was significantly correlated ($p = 0.004$) to higher nutritional dietary diversity.

Table 11: Results of three separate stepwise regressions for the three food security indicators in which initial explanatory variables are fraction of adults with income, fraction of children, social group membership, savings, table banking group membership, physical wealth index, participation in foraging, land ownership, land rental, crop farming, and participating in fishing or the omena business.

Variable	F value	Pr(<F)	Coefficient
Nutritional dietary diversity (MDD-S) explained by:			
Fraction of adults with income	9.480	0.00231 **	-0.25604
Fraction of children	7.390	0.00702 **	0.27575
Not belonging to a social group	7.037	0.00850 **	1.11532

Having savings or being part of a table banking group ¹⁰	7.987	0.00509 **	0.78516
Land owned (acres)	1.470	0.22657	-0.13905
Participation in crop farming	1.850	0.17497	-0.29875
Fraction of adults with income : not belonging to a social group	5.681	0.01790 *	-2.01137
Fraction of children : not belonging to a social group	5.771	0.01702 *	1.77336
Land owned (acres) : participation in crop farming	8.502	0.00387 **	0.33129
Economic dietary diversity (HDDS) explained by:			
Fraction of children	3.991	0.046796 *	0.6169
Not belonging to a social group	12.442	0.000497 ***	-0.6337
Perceived food insecurity (FIES) explained by:			
Fraction of adults with income	11.40	0.000849 ***	-2.36277
Fraction of children	19.41	1.56e-05 ***	2.06603
Having savings or being part of a table banking group	11.60	0.000766 ***	-0.77534
Physical wealth index	55.82	1.28e-12 ***	-0.72963

The correlation matrix results are shown in Figure 29. Correlation coefficients were considered statistically significant at $p < 0.05$ and non-significant correlations were omitted from the plot for clarity. The plot displays coefficient r -values (labelled in each box) and a colour gradient indicating the direction and magnitude of each correlation. R -values below 0.3 were considered to represent a small effect and thus only pairings with an r -value above 0.3 were considered (Field *et al.*, 2012).

This matrix shows several notable correlations between household resources. The physical wealth index was positively correlated with distance to land (i.e., wealthier people lived farther from their land). The physical wealth index was also positively correlated with the amount of savings (i.e., wealthier people had more savings). The physical wealth index and land ownership were negatively correlated with participation in the omena business (i.e., people with less resources were more likely to participate in the omena business).

The matrix also shows correlations between household resources and food security indicators. The physical wealth index, savings, and distance to land were negatively correlated with the FIES (reminder that higher FIES scores indicate feeling more food insecure - i.e., people with less resources/income and further from their land were more likely to feel food insecure). However, the physical wealth index and having savings were not correlated with MDD-S or HDDS (indicated by blank boxes on the graph). The number of people in the omena business (but not the fishing business) were negatively correlated with the number of crops grown.

¹⁰ The original regression was designed with savings and table banking separately; this resulted in coefficients that described benefits to MDD-S from having savings or participating in table banking, but no benefit from having both. Thus, these were combined into one binary variable indicating if the respondent answered yes to either.

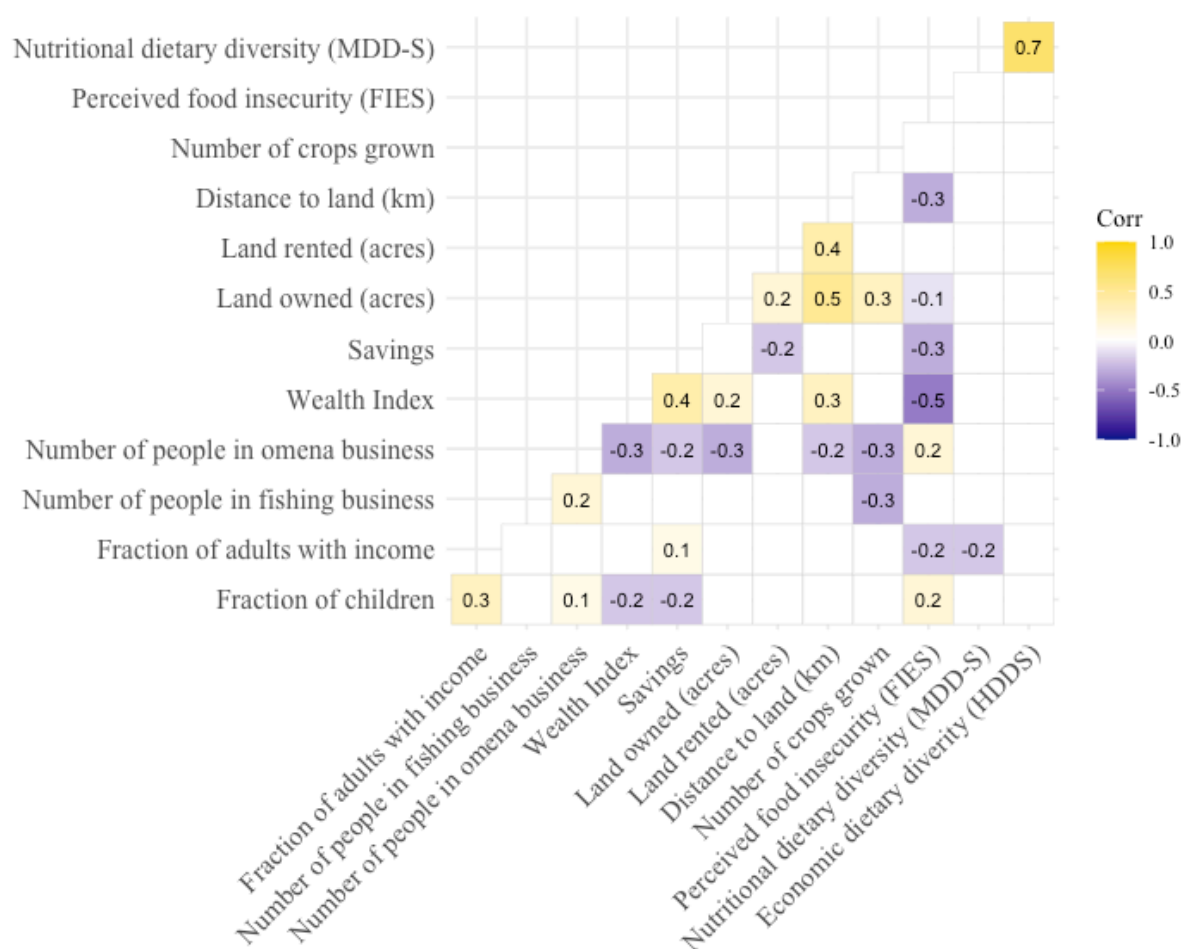


Figure 29: Correlation matrix of numerical variables indicating household resource and food security

What household resources affect what animal source foods a household ate yesterday?

To test whether the nutritional dietary diversity (MDD-S) was affected by livelihoods, ANOVA was used to test for differences in household resources between animal source food (ASF) consumption groups (fish, omena, eggs, multiple animal source foods, or no animal source foods). Only the physical wealth index was correlated with ASF consumed yesterday. Tukey test was used to distinguish which groups differed from each other in wealth. A boxplot of the results is shown in Figure 30, which shows that only the people who ate omena yesterday differed from the others by physical wealth index, with lower average wealth (mean = -1.03 compared to 0.131 for others).

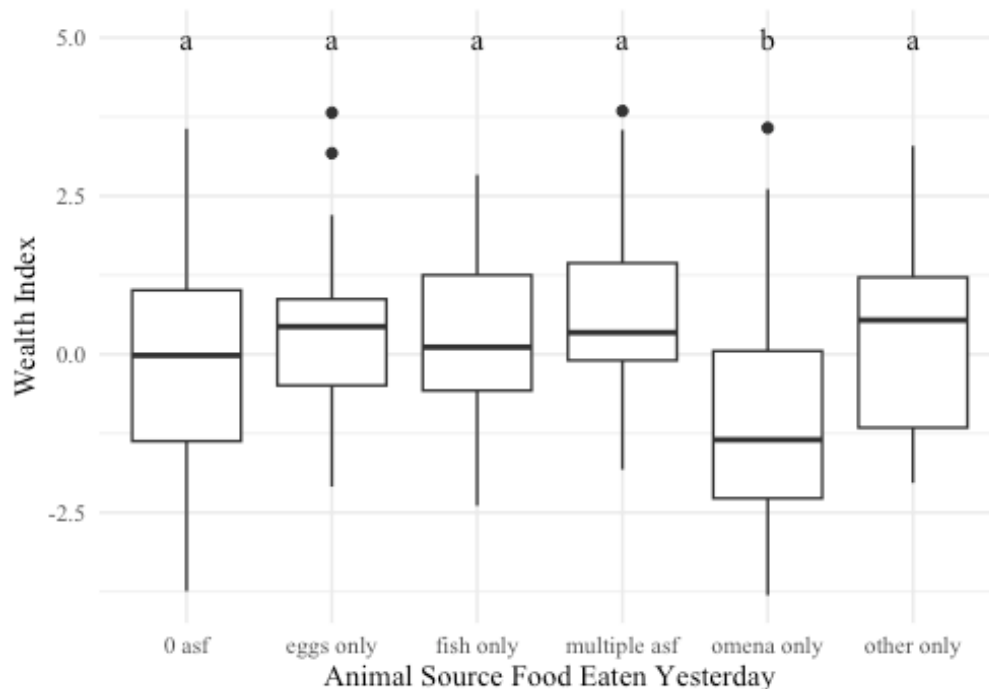


Figure 30: Significant differences in the average physical wealth index between those who only ate omena versus other animal source foods.

What factors are associated with fish consumption satisfaction?

The results of the chi-squared tests to examine whether participating in the fishing or omena businesses was correlated with the likelihood of eating fish or omena, respectively, are shown in Table 12. From this table, we see that the participation in the omena business is significantly ($p=0.02$) correlated with eating omena in the past 24 hours; in contrast, participation in fishing is not significantly ($p=0.94$) correlated with eating fish in the past 24 hours.

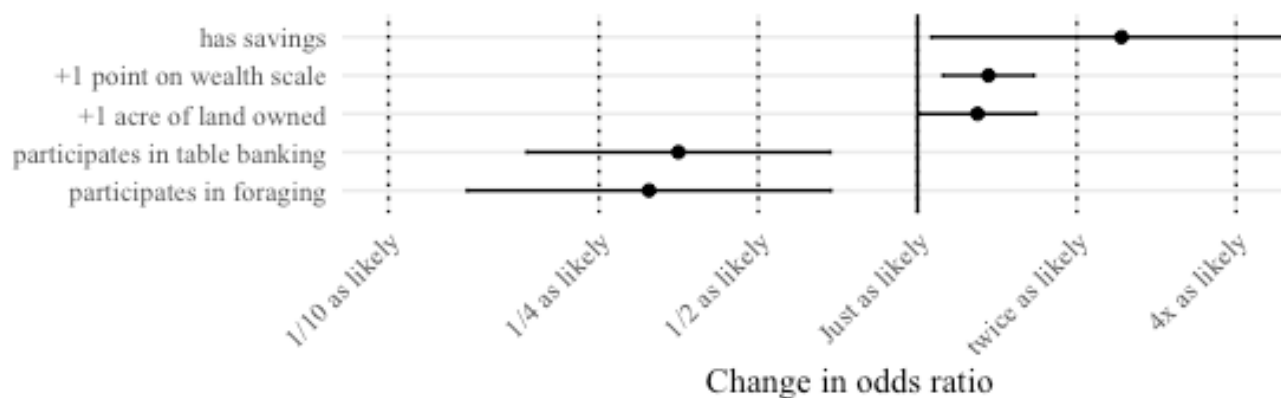
Table 12: Results of the chi-squared test assessing correlations between participation in the omena business or fishing compared to eating omena or fish, respectively.

Omena ($p= 0.02$)	Did not eat omena yesterday	Ate omena yesterday
Not involved in the omena business	68.4%	31.6%
Involved in the omena business	48.9%	51.1%
Fishing ($p= 0.94$)	Did not eat fish yesterday	Ate fish yesterday
Not involved in fishing	86.8%	13.2%
Involved in fishing	85.5%	14.5%

The stepwise regression results for wanting more fish or omena are shown as odds ratio plots in Figure 31. While all household resources were included in the stepwise regression, only the significant factors are presented in these graphs. These graphs show that wealth indicators were significantly correlated with satisfaction regarding fish and omena consumption. Wealthier people were more likely to want more omena and poorer people were more likely to want less omena.

Similarly, land ownership was significantly correlated with satisfaction with omena consumption, where people with more land were more likely to want more omena.

(a) wants more omena



(b) wants less omena

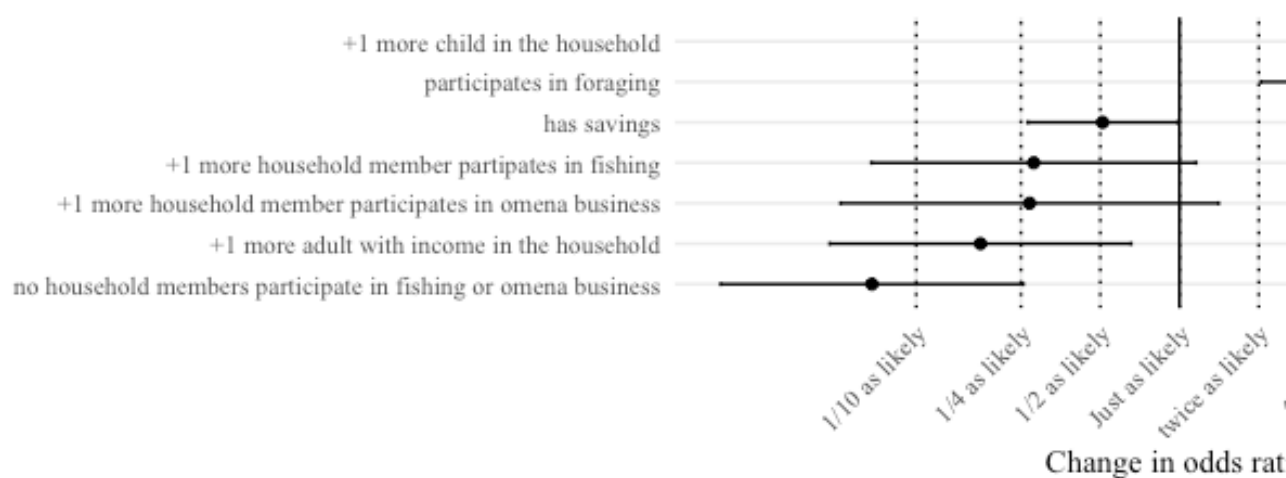


Figure 31: Using the results of the stepwise regression analysis to calculate coefficients and confidence intervals, this graph presents the odds of respondents (a) wanting to eat more omena and (b) wanting to eat less omena.

Summary of key results

- Financial capital (having savings or participating in table banking) was important for dietary diversity.
- Households with a higher fraction of income-generating adults had lower dietary diversity.
- Households with fewer resources engaged in social groups.
- Households who felt food insecure (FIES) did not necessarily have lower dietary diversity; actually, households with more diverse diets felt more food insecure.
- Households who used their land for crops had better dietary diversity.
- Households with more physical capital also had more financial capital (and possibly had more environmental capital, though the correlation between the wealth index and land ownership was weak).
- Households with less resources were more likely to participate in the omena business.
- Households participating in the omena business were more likely to eat omena (the same was not true for fishing).
- Households with more resources wanted to eat more omena; households with less resources wanted to eat less omena.

7.2.3 Dietary patterns: Identifying dietary patterns and assessing their relationship to different food security indicators

The results of the 24-hour diet recall showed that almost all respondents ate cereals and oil (Table 13). Ugali was eaten by 94% of respondents and porridge by 41% of respondents. Fish was the most commonly consumed animal-source food (ASF), with 49% of respondents eating fish or omena compared to red meat (10%), eggs (8%), white meat (2%), and organ meat (1%). Small fish (omena and fulu) were more commonly consumed than large fish (Nile perch, tilapia): of respondents, 37% (n=96 of 259) ate small fish whereas 15% (n=40 of 259) ate large fish. The only type of red meat consumed was beef, and the only type of white meat consumed was chicken. Fish, beef, chicken, and eggs were prepared usually by frying them with onion and tomato. Alternatively, some people simply fried these ASF, and one respondent noted putting small fish in soup.

Table 13: The types of dishes by category and the percent of respondents who ate those categories from the Household Resource and Intrahousehold Diet Questionnaires.

Food Category	% Respondents consuming that food category	Main Types of Dishes
Cereal	96% (n=320)	Ugali (boiled maize flour); porridge (maize, millet, sorghum, cassava flour); Baked goods (bread, mandazi, chapati, scones); pasta (spaghetti, insta-noodles)
Oil	91% (n=302)	Vegetable oil (for frying/sautéing)
Vegetables (other)	84% (n=279)	Tomato; onion
Sweets	83% (n=275)	Soda; candy
Misc	58% (n=193)	Tea, coffee, alcohol
Fish	49% (n=164)	Omena, fulu, tilapia, Nile perch, unidentified ssp.
Dark leafy greens	41% (n=136)	Local indigenous vegetables (apoth, sukumawiki, dek, osogu, kales, spinach, pumpkin leaves); cabbage
Dairy	28% (n=92)	Milk, yogurt
Legume	20% (n=65)	Beans, groundnuts, green grams, lentils
Red meat	10% (n=34)	Beef
Vegetables (Vit A rich)	9% (n=30)	Carrots, sweet potato
Fruit (Other)	9% (n=29)	Avocado; bananas, lemon; watermelon
Eggs	8% (n=27)	Eggs
Fruit (Vit A rich)	5% (n=17)	Mango, orange, papaya
White tubers	5% (n=16)	White potatoes, yams
White meat	2% (n=8)	Chicken
Organ meat	1% (n=2)	Liver; tripe

What foods are complimentary to or substitutes for fish?

In order to understand which dishes were likely to be eaten as part of the same diet (i.e., to characterise different diet types within the sample population), principal component analysis (PCA) was applied to the interhousehold dataset. In this case, the PCA analysis revealed four dietary patterns (Table 13). Each component describes an “either/or” pattern, where different consumers typically eat foods positively weighted with the component or the foods that are negatively weighted with the component. As a reminder, the eigenvalues represented how strongly that food was correlated with that component. Thus, for each component, positive eigenvalues were associated with one diet and negative eigenvalues were associated with the second diet. For example in component 1, red meat and fish have positive weightings, whereas omena have a negative weighting. This means people are either eating red meat and fish OR omena. Therefore, red meat appears to be complimentary to fish, whereas omena seems to be a substitution for red meat and fish. Component 1 also shows that indigenous leafy green vegetables and baked breads have a positive weighting and cabbage and porridge have negative weightings. Thus, people generally eat indigenous leafy green vegetables or cabbage but not both; people generally eat baked breads or porridge, but not both. These foods present as substitutes. Notably, key informants said that foods that had negative weightings for component 1 are all locally produced, whereas all foods that had positive weightings towards component 1 must be imported (in the case of cabbage, one respondent did grow it with the intention of both eating and selling it, but for most people, cabbage was sourced from outside the region).

The first four components described a total of 31.1% of the variance (the sum of the percentages listed in the left-hand column of Table 14), which is normal for these types of dietary pattern analyses (for example, see: Auma et al., 2019 and Galbete et al., 2017, whose PCAs also accounted for around 30% of the variance). What people eat in their diet is multifactorial, which is why the PCA often requires so many dimensions to describe all the variance. Key informants were unable to explain the differences in diets characterised by components 2 through 4, so these were discarded for the remainder of the analysis.

Table 14: The four dietary patterns identified by the first four components ('comp') of the MCA analysis, with the percent variation explained by each component in parenthesis, using 24 common dishes.

Comp	Positive contribution to the PCA score		Negative contribution to the PCA score	
Comp1 (10.2%)	Tea	0.67	Porridge	-0.74
	Baked breads	0.59	Tuber dishes	-0.41
	Rice dishes	0.45	Leafy greens dishes	-0.37
	Cabbage dishes	0.36	Omena dishes	-0.33
	Nile perch/tilapia dishes	0.28	Ugali dishes	-0.23
	Red meat dishes	0.24		
	Sweets or sweet drinks	0.21		
Comp2 (8.3%)	Ugali	0.78	Legume dishes	-0.47
	Leafy greens dishes	0.56	Porridge	-0.35
	Tea	0.43	Rice dishes	-0.31
	Red meat dishes	0.32		
	Omena dishes	0.25		
	Egg dishes	0.21		
Comp3 (6.7%)	Chapati	0.42	Pasta dishes	-0.46
	Legume dishes	0.39	Omena dishes	-0.45
	Egg dishes	0.36	Other vegetable dishes	-0.40
	Fruit	0.33	White potato dishes	-0.31
	Leafy greens dishes	0.32	Cabbage dishes	-0.26
	Chicken dishes	0.27	Fried breads	-0.21
Comp4 (5.9%)	Pasta dishes	0.48	Rice dishes	-0.40
	Other vegetable dishes	0.43	Omena dishes	-0.35
	Plantain dishes	0.41	Fried breads	-0.32
	Egg dishes	0.30		
	Tuber dishes	0.26		
	Chapati	0.23		
	Chicken dishes	0.22		

Do households with different resources eat different diets?

Using linear regression models, each component was compared with the household resource variables (fraction of adults with income, fraction of children, social group membership, savings,

table banking group membership, physical wealth index, participation in foraging, land ownership, land rental, crop farming, and participating in fishing or the omena business) and the food security indicators (food insecurity experience 'FIES', nutritional dietary diversity 'MDD-S', and economic dietary diversity 'HDDS'). The results of these models are presented in Table 15.

While FIES had a negative effect on component 1, the nutritional (MDD-S) and economic (HDDS) had a positive effect on Component 1. Having savings or table banking and not foraging also had a positive effect on component 1. Not participating in social groups had a negative effect on Component 1.

Table 15: Results of the stepwise regression for component 1 against household resources and food security indicators.

Variable	F value	Pr(<F)	Coefficient
Component 1 compared to food security indicators			
Food insecurity experience 'FIES'	10.31	0.00149 **	-0.07936
Nutritional dietary diversity (MDD-S)	193.48	< 2e-16 ***	0.54823
Economic dietary diversity (HDDS)	24.12	1.62e-06 ***	0.41310
Component 1 compared to household resources:			
Having savings or participating in table banking	11.651	0.000747 ***	0.9976
Not participating in any social groups	10.824	0.001144 **	-0.3764
Not participating in foraging	5.656	0.018131 *	0.4847

Summary of key results

- Ugali, porridge and vegetable oil were the key staples for the sample population.
- Fish was the most important animal source food.
- Small fish (omena and fulu) were more commonly consumed than large fish (tilapia and Nile perch).
- The main differentiator between diets were those with imported versus locally produced foods.
- Households with more resources ate diets with imported foods and had higher dietary diversity, but felt more food insecure.

7.2.4 Nutritional contribution of dinner to dietary requirements

The survey included 30 households across the wealth spectrum and thus likely to capture information across both better and worse-off families¹¹ (Figure 32), resulting in data for 30 male adults, 30 female adults, 16 female children and 11 male children. Of households, 29% (n=10 of 35) had a family

¹¹ Because sampling was through snowballing rather than random selection, I wanted to check that households across the wealth spectrum were represented in the sample so we could draw conclusions about the population based on wealth.

member present who did not eat. The only reasons that people present during the meal did not eat were (1) they weren't hungry or (2) the person was a child and was breastfed instead. Additionally, 71% (n=24 of 35) of households had food leftover after the meal. Only 6% (n=2 of 35) of households reported that not everyone ate as much as they wanted, explaining that someone had arrived late and there was not enough leftover food for them.

Meals generally consisted of an ASF dish, a leafy green vegetable dish, and ugali. Infrequent variations included pairing the meal with rice instead of ugali. All ASF and leafy green vegetable dishes were fried/sauteed in oil, often including onions and sometimes tomatoes and carrots. ASFs included omena, fulu, chicken, beef, Nile perch, tilapia, and eggs. Two families ate beans as a pulse instead of an ASF.

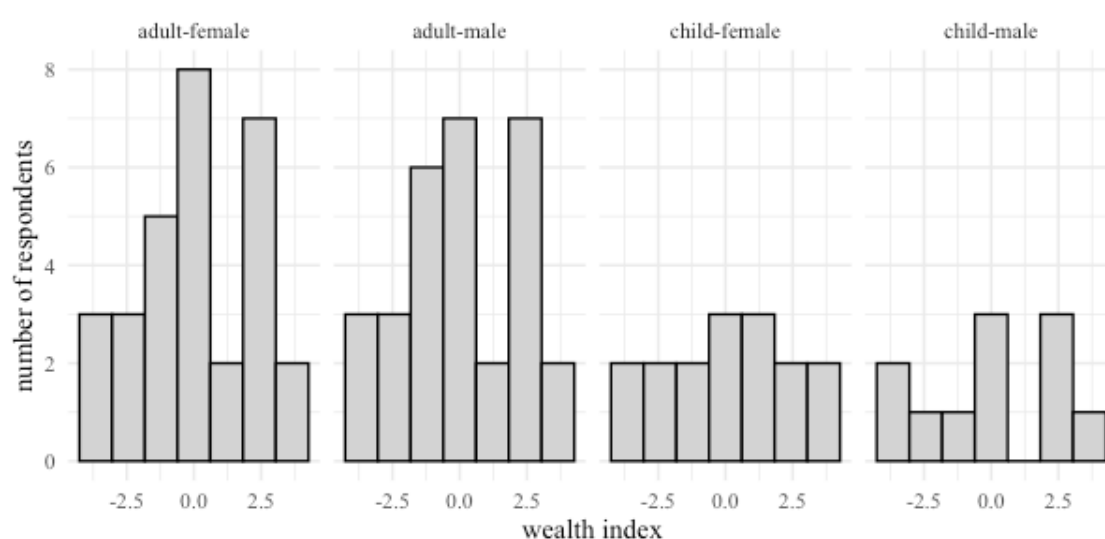


Figure 32: Distribution of individuals across the physical wealth index.

How often are households eating each type of animal source food?

The frequency of animal source food (ASF) consumption per month is shown in Figure 33. Wealth was negatively correlated with omena, fulu, and mumi (catfish) consumption and positively correlated with farmed tilapia consumption. Significant differences were also observed between certain religions and pond tilapia consumption, where Full Gospel and Protestant households consumed pond tilapia significantly more frequently than other religions. Households identifying as Meru ethnicity ate pond tilapia significantly more frequently than other ethnicities. No other correlations were found between religion or ethnic group for any other ASFs.

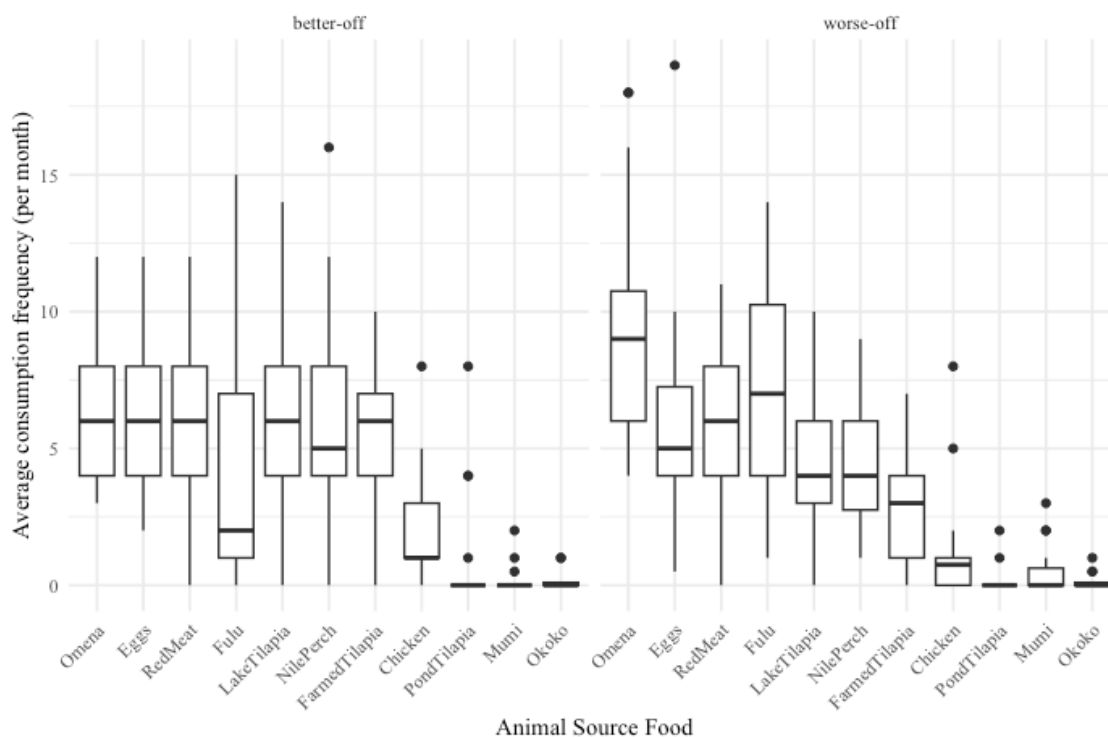


Figure 33: Monthly frequency for all commonly consumed ASF by wealth group. Significant differences between wealth were apparent for omena, fulu, mumi (catfish), and farmed tilapia.

What percentages of the recommended nutrient intake is dinner providing?

The nutrient composition of each fish is described in Table 16, showing that larger fish had higher levels of protein, but smaller fish had higher levels of all micronutrients. Figure 34 compares the nutrient composition for all recorded foods, showing that animal source foods, ugali, and rice seem to make the largest nutrient contributions to the recommended nutrient intake (RNI).

Table 16: The nutrient composition of aquatic food samples collected from the study area. Omena, fulu, Nile perch, 400g farmed tilapia, 200g farmed tilapia, and 200g wild tilapia, all converted to dry matter basis. While omena and fulu are eaten dried, the others are usually eaten fresh.

Nutrient	Omena (whole)	Fulu (whole)	Nile perch (flesh only)	Tilapia (flesh only), wild, 200g	Tilapia (flesh only), farmed, 200g	Tilapia (flesh only), farmed, 400g
Protein (%)	61.8	56.6	86.4	86.0	78.1	80.6
Fat (%)	11.0	8.7	3.79	2.99	6.23	6.74
Iodine (mg/kg)	0.71	0.70	0.24	0.38	0.17	0.21
Zinc (µg/g)	248	185	24.9	26.7	35.0	33.0
Iron (µg/g)	76.3	226	23.1	29.4	23.3	15.0
Calcium (µg/g)	34800	37500	571	646	797	775
Selenium (µg/g)	1.35	1.52	0.98	0.69	0.55	0.67
Vitamin A (µg/100g)	42.5	30.8	<21	<21	<21	<21
Vitamin B12 (µg/100g)	45.6	36.2	3.08	0.62	2.49	1.13

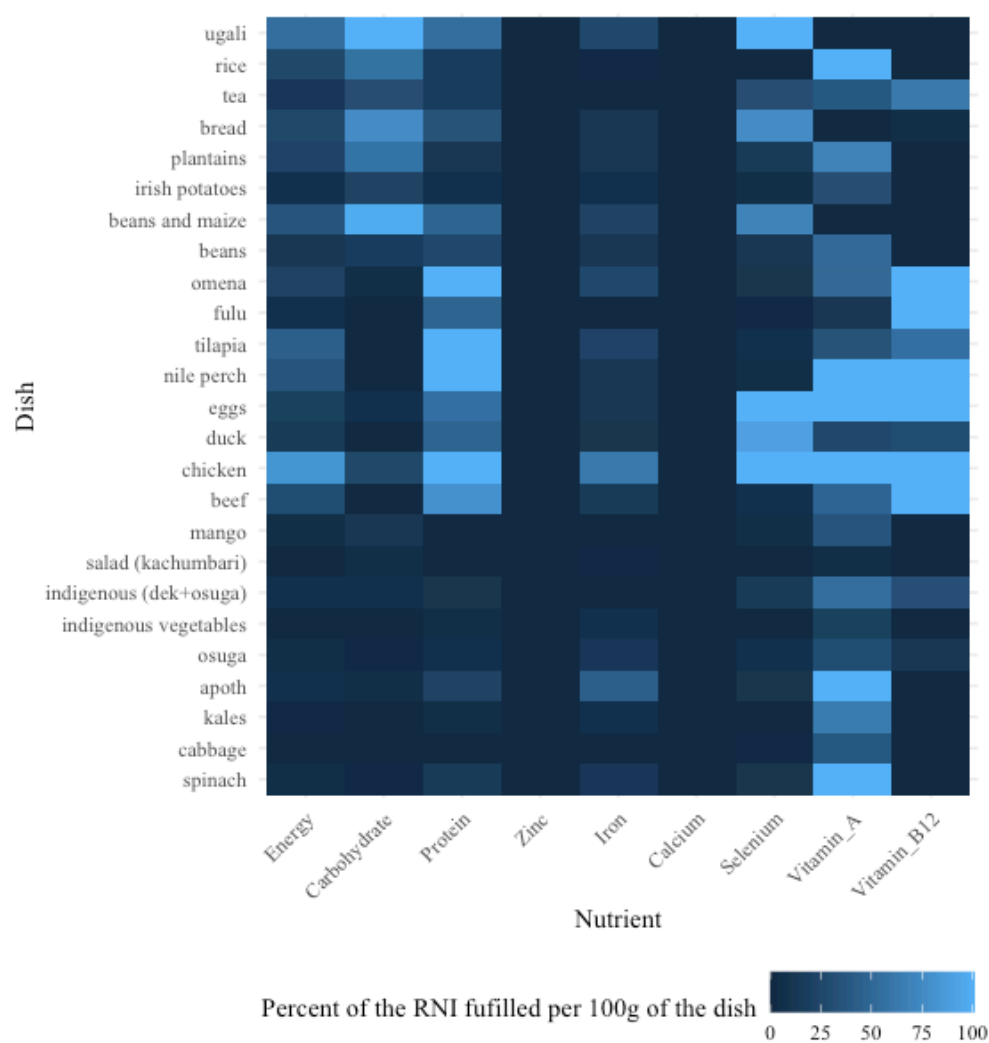


Figure 34: The percent RNI for each nutrient per 100g of each dish listed by the participants. For example, this figure shows that 100g of omena fulfils close to 100% of the average RNI for Vitamin B12.

Are there differences in nutrient intake between household members by gender, generation, or wealth?

Significant differences in the nutritional contribution of dinner to recommended intakes were measured between household members and wealth groups using F-tests (Table 17). Notably, significant differences in carbohydrate, zinc, iron, and Vitamin A intake were observed between household members and differences in carbohydrate, calcium, and Vitamin B12 were observed between wealth indices. For each of the significant correlations, I ran new linear models including both ‘physical wealth index’ and ‘family members’ with eta-squared tests, and the results of which are presented in Table 18. As a reminder, the eta-squared values explain how much of the variance is explained by the variable.

Table 17: The average percent of the RNI that dinner provides for each nutrient and F-test results for each nutrient when tested against household members and the physical wealth index.

Nutrient	Average intake (as a % of the RNI, plus or minus the standard deviation)	Household member	Physical wealth index
Energy	72.1% $\pm$ 32.4	F3,83 = 1.46	F1,85 = 0.556
Carbohydrate	117% $\pm$ 58.3	F3,83 = 8.38 (p = 0.0336)	F1,85 = 4.663 (p = 6.23e-05)
Protein	220% $\pm$ 169	F3,83 = 0.248	F1,85 = 0.059
Fat	∞	F3,83 = 2.294	F1,85 = 0.616
Zinc	0.0177% $\pm$ 0.0225	F3,83 = 3.148 (p = 0.0293)	F1,85 = 1.329
Iron	78.7% $\pm$ 60.2	F3,83 = 16.71 (p = 1.39e-08)	F1,85 = 3.224
Calcium	0.287% $\pm$ 0.504	F3,83 = 1.405	F1,85 = 4.585 (p = 0.0351)
Selenium	101% $\pm$ 89.6	F3,83 = 1.203	F1,85 = 0.069
Vitamin A	183% $\pm$ 135	F3,83 = 3.2 (p = 0.0275)	F1,85 = 0.265
Vitamin B12	838% $\pm$ 1369	F3,83 = 1.116	F1,85 = 5.62 (p = 0.02)

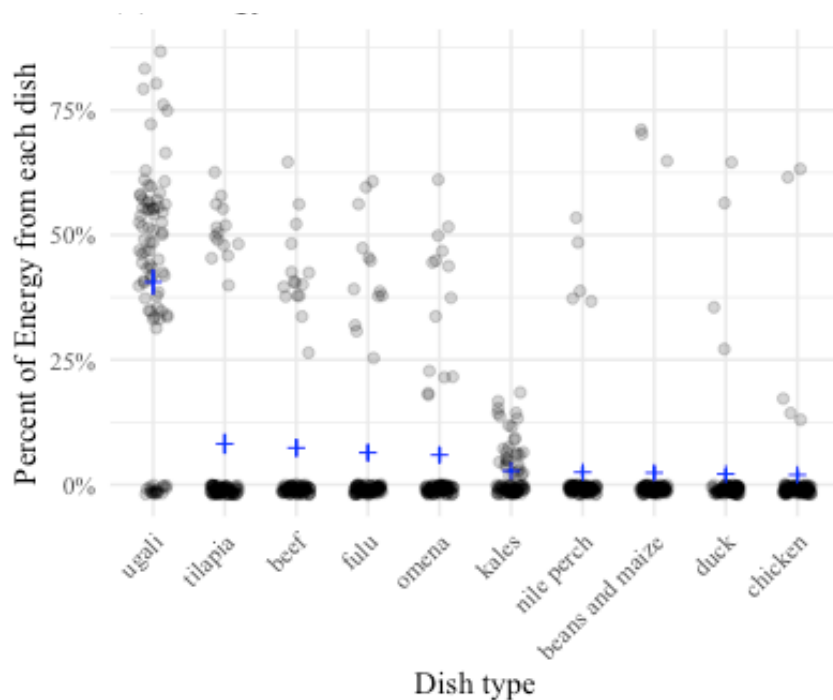
Table 18: Linear regression ANOVA summary results for each nutrient when tested against the physical wealth index and household members.

Variable	Coefficient	P-value	Eta-squared (η^2)
Carbohydrate			
Physical wealth index	-5.883	0.0157*	0.07
Family member			0.25
Female adult	0	-	
Male adult	-40.394	0.0500*	
Female child	-40.394	0.0115*	
Male child	-46.363	0.0108*	
Zinc			
Family member			0.10
Female adult	0	-	
Male adult	-2.158e-05	0.9969	
Female child	-1.504e-02	0.0281 *	
Male child	-1.613e-02	0.0384 *	
Iron			
Family member			0.38
Female adult	0		
Male adult	80.970	6.09e-09 ***	
Female child	1.747	0.9074	
Male child	34.247	0.0478 *	
Calcium			
Physical wealth index	-0.04995	0.0351 *	0.05
Vitamin A			
Family member			0.10
Female adult	0	-	
Male adult	10.36	0.7589	
Female child	-65.07	0.1106	
Male child	-111.18	0.0177 *	
Vitamin B12			
Physical wealth index	-149.42	0.02 *	0.06

What foods are contributing the most nutrients?

A descriptive analysis of each food's contribution to Energy and Vitamin B12 is displayed in Figure 35. The top ten contributing dishes for each nutrient position on the right show what percent of each nutrient comes from each dish when that dish is consumed (the points, representing individual data points) and what percent of the respondents ate that dish (the blue cross, indicating the mean and the standard error). Graphs for all other nutrients are shown in the appendix. In summary, ugali (maize-based dough) was the main contributor for all nutrients except for calcium (where omena and fulu were the main contributors), Vitamin A (where kales were the main contributors), and Vitamin B12 (where beef was the main contributor for better off people and tilapia was the main contributor for worse off people).

(a) Energy



(b) calcium

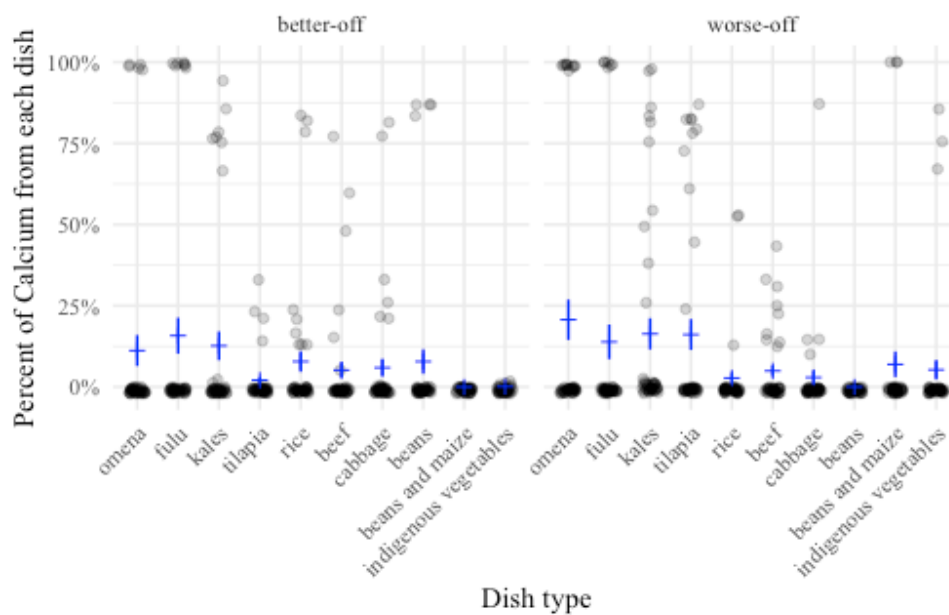


Figure 35: These graphs demonstrate which foods are and by how much each food is contributing to (a) energy, (b) calcium.

Summary of key results

- Recipes were monotonous (mainly a large portion of ugali with sides of fried ASF and fried/sauteed leafy green vegetables).
- Omena was a significant source of nutrients for worse-off households; better off households were more likely to eat tilapia and Nile perch than worse-off households.
- Compared to larger fish (tilapia and Nile perch), smaller fish (omena and fulu) were rich in calcium, iron, iodine, Vitamin A, and Vitamin B12.
- Ugali was the most important food source for most nutrients.
- Compared to worse-off households, better-off households reached a lower percentage of their RNI for carbohydrates at dinner (due to smaller portions of ugali).
- Compared to worse-off households, better-off households reached a lower percentage of their RNI for calcium at dinner (due to lower omena consumption and higher chicken/meat consumption).
- Compared to worse-off households, better-off households reached a lower percentage of their RNI for vitamin B12 at dinner.
- Children reached a lower percentage of their RNI for zinc than adults.

- Males reached a higher percentage of their RNI for iron than females (due to differences in RNI requirements rather than differences in food intake).

7.2.5 Worsening experiences of food security: “Life was better then.”

The analysis found that overall, key informants believed that food security in the area was worsening over time. Key informants noted that even previously rich people were now suffering and struggling to put food on the table. Unanimously, key informants said that “life was better” twenty to thirty years ago compared to the present day regarding their livelihoods and food security. The main difference people noted between now and when they were a child was about feeling full and satisfied. They tied this to food commoditisation, a reduction in local food production, and a greater reliance on imported food items, creating a sense of nostalgia (see also: Prince, 2008):

I used to eat well... now, there is a scarcity of food. (Male Elder in a hillside agricultural village)

Now, I look for money to buy food. (Woman resident in Sindo)

We never valued money so much. (Male Elder in Roo)

People pinpointed three main foods present in their diet as a child that were no longer available: fish, milk, and termites. A wide variety of fish species were no longer available (for example, respondents mentioned fuone, ningu, noheree, rawa, and seu as fish species that were no longer available). Now, tilapia was more abundant. Along with a decreased variety of fish, respondents explained that they also ate fish less frequently. Fish were no longer gifted (only sold, as found by Allegretti, 2019, and potentially caught by children illegally, as I observed) and some people relied on only vegetables. They tied this to perceived declining fisheries: “There used to be more fish”, referring to both species diversity and quantity (Female elder in a hillside agricultural village). Termites were also more abundant: during their childhood, these insects could be harvested in large enough quantities for the household’s dinner. Now, termites are found in smaller quantities, sufficient only for a snack. Ants, termites, crickets, grasshoppers, lake flies and bees are consumed by Luos specifically (Christensen et al., 2006; Halloran et al., 2015), but the participants in the present study only mentioned rare consumption of termites.

Other food practices have also been abandoned due to poor availability. Elders recalled that they used to siphon blood from cows to make a drink, which they no longer practice due to the scarcity, bovine diseases, and monetary value of cows, particularly in relation to paying for school fees. They also remembered that milk used to be produced entirely from the village, whereas now, most of the milk is imported. Traditional practices, like storing milk in a calabash, or eating ugali made with fermented milk, are no longer practiced due to reduced accessibility of milk.

A wider variety of income-generating opportunities were available now compared to twenty or thirty years ago. For example, the boda business (motorcycle taxi services) became accessible with imported and more affordable motorbikes in combination with microloans. This may be due to (1) increased commoditisation of food driving a need for cash for purchasing, (2) decreased catch per unit effort and reduced reliability of fishing. Elders reflected that in the past, fishermen were fewer and fish were more plentiful. They also experienced that, in contrast to Nile perch, which has decreased, omena has increased and is available year-round compared to only seasonally during their younger years. More recently, there has been a shift to target omena in the absence of Nile perch.

Whereas a fisher's income used to be sufficient to support the entire family (often including several households), women became increasingly responsible for additional income-generation. In contrast to their parents' generation, "Mothers now will work hard to give the child what they desire" (A fisher's wife in Sindo). In these cases, the mother's ability to purchase food was a key driver in household food security. Family members in worse-off households were dependent on the mother's ability to purchase food.

In summary, food security has worsened over time across the study area. This was attributed to the commoditisation of food, fisheries biodiversity decline, reduced availability of milk-producing cattle, and unavailability of forageable foods. Due to reduced availability of locally accessible foods, food acquisition was contingent on purchasing power. Thus, both men and women were increasingly under pressure to generate income for food security.

7.3 Discussion

7.3.1 The state of food security in the study area

The state of food security in the study area was determined by quantifying dietary nutritional adequacy (nutritional dietary diversity MDD-S), economic access to food (economic dietary diversity HDDS), and perceived food insecurity experiences (FIES) in the study area (see section 6.2.1). This study showed that **food insecurity is severe in the study area**. In terms of dietary nutritional adequacy, this study showed that many people in the study area were unlikely to have nutritionally adequate diets. The average MDD-S was below 5, suggesting that most people did not have the minimal dietary diversity required for a nutritionally adequate diet (FAO, 2016). This average dietary diversity score was lower than the national average (Global Diet Quality Project, 2021). Lui et al., (2022) also found that children in Western Kenya had low dietary diversity scores. Furthermore, the present study found that economic access to food was low. The average HDDS score for the 33% of household with the highest HDDS score was only 7.08 out of a possible twelve, and most people were significantly below that average. Additionally, over a third of the respondents experienced severe food insecurity in the past year. Future interventions can use these dietary diversity scores and FIES as baseline metrics to assess the impact of programmes aimed towards

improving economic access to food and experiences of food security (Swindale & Bilinsky, 2006; Ballard et al., 2013). The result that the nutritional (MDD-S) and economic (HDDS) dietary diversity scores were correlated but not exactly evidences their differences and the need to use both or carefully consider the use of one over the other.

7.3.2 Important food types

This study also identified key foods underpinning diets. Cereals (mainly maize) were the most common food source, followed by oil, vegetables, and sweets. The lack of dietary diversity was apparent through food combinations and meals. Main meals were centred around ugali, with smaller accompanying dishes based on vegetables or animal-source foods (ASF). Variations in recipes was minor and likely due to personal preference and availability of ingredients. For example, Nile perch and tilapia were either fried or fried with onions, and tomatoes. One person noted that omena could be cooked in a soup with milk. Leafy green vegetables were cooked in oil and some people added milk, tomato and/or onion. Diets with low dietary diversity are often characterised by a dependence on starchy staples with lower inclusion of fruits, vegetables, and animal source foods (Hawkes & Ruel, 2008). Monotonous diets were also observed in Uganda (Holmager et al., 2021) and Burkina Faso (Lykke et al., 2002). The trend towards convenience formats described by key informants may further reduce the variance and nutritional quality of meals as foods that are shallow fried rather than boiled have lower nutritional quality (Alozie & Ene-Obong, 2018; Tadesse Zula et al., 2021; Zula & Desta, 2021).

These results also suggest that **diets may be lacking in nutritional adequacy**. While cereals and vegetables are key sources of nutrients, oil and sweets are defined as ‘nutrient poor’ due to their high energy to nutrient ratios (Drewnowski, 2005). Thus, **the ubiquity of these nutrient-poor foods signalled that a ‘hidden hunger’ may exist**, commonly defined as a diet sufficient in calories but deficient in nutrients (Burchi et al., 2011). Globally, economic growth has reduced the degree of overall hunger but not that of hidden hungers, which depend on micro-level interventions (Gödecke et al., 2018). Thus, the study area may require context-specific interventions – particularly in regard to addressing inequalities (Lowe, 2021) – to improve nutritional quality of the diet.

7.3.3 Links between food security and household resources

Several household resources were linked to food security indicators, as shown in section 6.2.2. As shown by the correlation matrix, wealth (indicated by the physical wealth index, having savings and having more adults with income) was important for feeling food secure (FIES) but not for having nutritional adequacy (MDD-S) or being able to afford a diverse diet (HDDS). In other words, **more resources (i.e., more wealth) did not result in more diverse diets**. Low dietary diversity is likely a reflection of the monotonous diet that is pervasive throughout economic classes. **The poor availability of diverse foods or the cultural affinity to monotonous diets may be more relevant**

than affordability to the low dietary diversity scores (as discussed in 6.3.1). Rather than affecting the diversity of consumed foods, wealth may have affected the quantity of foods eaten, which will be examined in section 6.3.9 'Nutrient intake at dinner'. Despite that the diets were monotonous, the two different measurements of dietary diversity (nutritional MDD-S and economic HDDS) did indeed represent different outcomes and should be considered separately, evidenced by the fact that MDD-S and HDDS had an r-value of 0.7 in the correlation matrix.

The result that some but not all household resources were correlated with each other evidences the need for a Sustainable Livelihoods approach and consideration of multiple capitals contributing to 'wealth'. Physical capital (the physical wealth index) was associated with financial capital (savings) and environmental capital (land owned). Land ownership paired with crop farming also improved the economic dietary diversity score (HDDS) : this positive correlation between land ownership paired with crop farming and the ability to afford food showed the value of land for food security, where **income from crop sales likely led to increased purchasing power in markets**. Indeed, crop-farmers used land mainly for maize, an important cash crop identified by key informants. Very few farmers grew millet or cassava, in contrast to records from the late 1990s, when most farmers were growing millet and cassava (Geheb & Binns, 1997). The number of farmers growing beans has also doubled since the 1990s (Geheb & Binns, 1997). The average amount of land owned was about the same as late 1990s records, showing that plot division for inheritance did not lead to smaller land plots (Geheb & Binns, 1997). Rather, land ownership was only correlated with improved likelihood of nutritional adequacy (MDD-S) when it was used for crop farming instead of allowing it to be idle. This may be because landowners who were able to exploit their land generated income that improved food security. In contrast, landowners not participating in crop farming lacked the knowledge and/or capital (e.g., for irrigation and ploughing equipment) to exploit the land. Despite being so close to the lake, these farmers are unable to utilise the lake's vast water supply. Observationally, the only farmers who had irrigation systems seemed to be those sponsored by the Victory Farm's outgrower programme. Those who rented land from landowners to cultivate, regardless of its use for crop farming, did not benefit from improved food security, likely due to the additional rental expense reducing profit that could be directed to improve the household's food security. The descriptive summary showed that subsistence-oriented farming was negligible (most crops were for the purpose of selling but a small portion could be retained for household consumption).

The correlations between food security indicators and household resources suggested that ***perceived food security (FIES) was largely based on money***. Because of this, those lacking money may have turned to foraging: while foraging was not significantly associated with any outcome variables in the statistical analysis, qualitative data analysis suggested that foraging was important for the poor in acquiring indigenous vegetables. In lacking financial capital, worse-off families were heavily dependent on environmental capital (natural resources provided through fisheries and foraging) for food security. Foraging was mainly for indigenous vegetables – one key informant confessed that,

although illegal, some people still hunt in groups for bushmeat like small antelopes (genus *Madoqua*). Bushmeat consumption in the area warrants further research. While everyone ate indigenous vegetables, the wealthier could purchase them from markets whereas the poor would forage them. Thus, the importance of foraging may have been lost in my dietary analysis because I only recorded the type of food and not the source (everyone was eating apoth, a leafy green vegetable, but some purchased it from markets whereas others foraged for it, which was captured in my qualitative but not quantitative data).

While foraging on land was for subsistence, the equivalent in water focused on income-generation. Fishers lacked both financial and physical capital – they were not recipients of reliable salaries and did not own their own boats or nets – and were thus disproportionately reliant on fisheries for income generation and food security. Access to fishing is thus more costly and riskier than foraging on land (Eggert & Lokina, 2007; Thiery et al., 2016; Thiery et al., 2017; Whitworth et al., 2019). Further emphasising their reliance on fisheries resources, respondents in the omena and fishing business grew less crops, possibly as a result of landlessness or time spent away from the homestead engaged in their fishing and omena businesses. **People participating in the omena business may be disproportionately reliance on fisheries** considering that participation in the omena business (but not the fishing business) was associated with poverty.

As a result of a commoditised food system, feeling food secure (having a low FIES) was likely dependent on feeling financially secure enough to make food purchases. However, **feeling food insecure was not always in alignment with being food insecure**. The result that households with a higher fraction of adults with income have lower nutritional dietary diversity could be explained by time limitations: households with less resources (and thus poorer food security) may need more of their household members to participate in income generating activities (e.g., elders may not retire but rather continue working if the household is resource poor). These lower-resource households may benefit from being part of social groups that can support them (having a larger fraction of adults with income decreases nutritional dietary diversity (MDD-S), with a much larger effect if the household is not belonging to a social group). Conversely, having a higher fraction of children may require more time spent on childcare and less on work, so not participating in a social group may allow more time for childcare and income-generating opportunities. As having a higher fraction of children was associated with a better ability to afford a nutritionally diverse diet (positive correlation between fraction of children and HDDS), households with a higher fraction of children may be lightly better off, thus not needing the support offered by social groups. Or, this may be because respondents with proportionally more children to care for had a heightened awareness of their responsibility to feed their dependents; households with more adults with income may have had a false sense of security. The explanation of these results need further investigation.

7.3.4 Food patterns associated with food security

Using PCA, this study characterised dietary patterns that were associated with food security. The variables significantly correlated to component 1 indicate that, compared to people eating local foods (porridge, tuber, leafy green, omena, and ugali dishes), people eating imported foods (tea, breads, rice, cabbage, Nile perch/tilapia, red meat, and sweet dishes) tend to have a larger dietary diversity, have savings or participate in table banking, do not forage, and participate in social groups – in other words, **people who rely more on social and financial resources and less on environmental resources are more likely to eat imported foods. People with more diverse diets also tend to eat imported foods.**

The associations with Component 1 indicate that households with social and financial resources (savings, table banking, and social groups) and more diverse diets are likely to eat imported foods (tea, baked breads, rice, cabbage, Nile perch/tilapia, red meat, and sweet dishes). Foraging is associated with eating locally available foods (porridge, tuber, leafy green, omena, and ugali dishes). Due to the low r-squared value in the PCA analysis, additional factors other than those tested in the regressions (e.g., personal preference) likely affected dietary patterns. The utility and conclusions drawn from the dietary patterns analysis may be limited.

Financial capital (table banking and savings) was associated with food security because it increased household's ability to purchase a more diverse diet. Furthermore, **the likelihood of having a nutritionally adequate diet (MDD-W) was associated with the ability to afford a nutritionally adequate diet (HDDS)**, evidencing the commercialised food system and connections between wealth and food security. A diverse diet was largely contingent on the ability to purchase imported foods, since a lack of agricultural technology resulted in a low variety of local products. **The ability to afford and consume foods imported into the study area improved a household's food security**, evidenced by associations between the component 1 diet and wealth, FIES, MDD-S, and HDDS. Wealthier people were eating diets with tea, baked goods, rice dishes, cabbage dishes, and sweets – all of which are foods that are not grown locally and must be brought into the study area. The main carbohydrate source was maize, which was mainly grown as a cash crop rather than for subsistence. In contrast, poorer consumers' diets were reliant on porridge, tuber dishes, leafy green dishes, and omena dishes, all of which are locally produced. Porridge was also commonly consumed in Zimbabwe (Merchant et al., 2005) and Burkina Faso (Lykke, 2002). Yet, nutritionally adequate dietary diversity (MDD-S) was not correlated with feeling food secure (FIES). Thus, people judge their own food security based on what foods they can afford to buy rather than what they are actually eating. Education around the nutritional value of cheap, locally available foods (like omena, indigenous leafy green vegetables, and fruits) may help people feel more food secure and have better satisfaction and experiential (subjective) food security.

7.3.5 The value of animal-source food consumption

The role of animal source foods (ASF) was extremely important for dietary diversity and was also determined by wealth. **Those with poor dietary diversity were characterised by low animal source food consumption – both in amounts and diversity.** Thus, due to low dietary diversity scores and particularly for those not eating any ASF, any increase in ASF consumption is likely to have nutritional benefits. Low dietary diversity scores and the importance of ASF in diets with low diversity was also found in Ethiopia (Workicho et al., 2016).

ASF consumption frequency varied by wealth group (Figure 29). **Better-off people ate a variety of animal source foods throughout the month, whereas worse-off people were more heavily reliant on omena and fulu.** Worse-off people ate less eggs, wild tilapia, farmed tilapia, Nile perch, and chicken, which are more expensive foods. **Notably, worse-off ate much less farmed tilapia, indicative of its inaccessibility for poorer consumers.**

Residents in the study area reported consuming increased amount of farmed fish, but were still mainly reliant on fisheries for tilapia and Nile perch consumption. The increase in farmed tilapia consumption supplied by local aquaculture was apparent, with 52.9% of respondents eating farmed tilapia now versus only 5.79% as children. Because the difference in consumption of wild tilapia was not as drastic (79.5% of respondents now compared to 66.8% of respondents as children), this trend is apparent for farmed tilapia only and not tilapia generally. This suggests that the emergence of local aquaculture was supplying fish directly to local consumers, in contrast to findings from the interviews. However, while many people eat farmed tilapia generally, frequency data would provide greater insights into its relevance and is worth collecting in future studies. Because, very few people thought farmed tilapia was easier to find or more affordable than wild tilapia or Nile perch, it is likely that consumption frequency is low. Thus, **people in Sindo are still heavily reliant on fisheries for large fish for consumption.** Only three respondents were also employees of a fish farm and thus comparisons between households with and without fish farm employees would have lacked statistical power. Future studies in this or similar study areas should use stratified sampling to examine differences in food security between households with and without fish farm employees.

Wealthier people were more likely to eat fish, chicken, egg and red meat dishes, which were more expensive than omena despite all being of local origin. Egg consumption was low, perhaps because eggs may not be a common dinner food; however, the qualitative work described food taboos that might be resulting in low egg consumption. Studies from Tanzania (Ochieng et al., 2017; Moreau & Garaway, 2018; Bundala et al., 2020) and Madagascar (Rakotomanana et al., 2020) have also described low egg intake. Chicken has not penetrated the local market as a cheap ASF, unlike in other areas (e.g., Brazilian chicken in Ghana; Sumberg et al., 2016), potentially due to the expense

and difficulty of obtaining broiler poultry feed in such a rural area. Locals also express a taste preference for the local chicken varieties, which are free-ranging scavengers and slower growing than the broiler chicken.

Nile perch and tilapia were the most frequently consumed ASF, as also described on the Tanzanian shores of the lake (Malenganisho et al., 2007). Of all the indicators, only financial capital (having savings) was associated with a higher likelihood of eating fish (Nile perch and/or tilapia), as found by Fiorella et al., (2014). But in contrast to Fiorella et al., (2014), who did not disaggregate fish by size (large vs small), the present study found differences in large fish versus small fish consumption: while almost all respondents included omena in their diets, wealthier people were more likely to also eat Nile perch and tilapia. Longer-term, omena may have replaced haplochromids and other fish species that used to be consumed locally but are now extremely endangered (Chapter 3). In the absence of a diverse array of affordable fishes and their replacement by Nile perch, Nile tilapia, and omena, only omena appears as the only truly affordable option for all local consumers.

7.3.6 The importance of omena

While omena was a staple food for the entire community, it is particularly important for the poor. The poor relied on it as the only ASF consumed in diets that were barely diverse enough for adequate nutritional intake. While many people ate only omena regardless of their MDD-S, people with MDD-S below five were more likely to eat omena or no animal source food at all. Compared to people eating no ASF at all, the people eating omena (and no other ASF) were poorer yet had more nutritionally diverse diets. In other words, **omena – even more than forageable leafy green vegetables – were critical sources of nutrition and dietary diversity for the poor.** Dietary inclusion of omena is disproportionately important compared to other foods because including any ASF is critical to achieving the minimum dietary diversity required for nutritionally adequate diets. Access and inclusion of omena in diets may be the reason that malnutrition rates along the lakeshore are lower than in nearby agricultural areas (Geheb et al., 2008). Thus, **these small fish were a critical animal source food for the poor in the study area, likely because they were affordable and portionable.** Ohiokpehai et al., (2007) also found that 46% and 37% of young children ate omena and fish respectively due to their affordability and ubiquity, comparable only to that of maize and foraged indigenous kales. Furthermore, small fish were the only frequently consumed ASF by young children living on the Kenyan shores of Lake Victoria (Ferguson et al., 2015). Their portionability was a key component of affordability: people could purchase omena in any quantity, depending on whatever money they have that day, in contrast to other fish species that were sold in pieces with set prices. People typically bought omena to eat that day if they were poor and living day-to-day, whereas wealthier people bought a portion of omena for the entire week. Some people reported that omena could be stored for up to three months, although preliminary research on its quality and nutritional degradation over time shows fungal and bacterial contamination concerns with longer-term storage (Wessels et al., 2023).

The decline in terrestrial ASF (insects and bushmeat) may also suggest an increasing reliance on omena. Edible insect availability is linked to forest cover in other areas of East Africa, and their declining availability may be due to deforestation (Okia et al., 2017). The Kenyan National Guidelines on Nutrition and HIV/AIDS recognises termites as a traditional animal source protein, recommending conservation, harvesting, and, during lean periods, consuming termites in rural areas to support food security (Republic of Kenya, 2006). Termites in the Kenyan Lake Victoria region are rich sources of iron and zinc (Christensen et al., 2006). However, as Kenyan food standards are adopted from international standards that have been mainly designed for Europe and North America, Kenyan regulations on entomophagy are generally lacking (Halloran et al., 2015). Insects in Kenyan legislation are in regard to food safety, framed as food contaminants that should be eliminated rather than sources of nutrition (Halloran et al., 2015). The Kenyan Bureau of Standards is developing legislation regarding insects as food and feed (Halloran et al., 2015). Endangered, marginalised, and underutilised foods are becoming less relevant globally due to their inability to adapt to the intensification of modern food systems and unsustainable harvesting practices (Zocchi et al., 2023).

Omena was also important for the poor's livelihoods. In particular, the omena drying business was a strategy employed by poor women for income. Furthermore, participation in the omena drying business enabled poor households' access to omena for consumption. This was evident through the results, where participation in the omena drying business was negatively correlated with wealth and positively correlated with omena consumption. Thus, the omena drying business was a highly accessible income-generating activity for poorer women that also supplied their household with omena. Moreau and Garaway (2021) also described the importance of women's engagement in the fish value-chain for household food security. While omena drying in the present study provided omena that was disproportionately important for these poorer households, it was insufficient to improve overall food security: participation in the omena-drying business was unrelated to food security indicators and these households' food security require support. For those with lower wealth, their food security could be improved by increasing their social support. Social capital (social networks) were important for feeling food secure, having nutritional adequacy, and being able to afford food. For instance, households with women participating in table banking were more likely to have nutritional adequate diets.

Notably, the direct contribution of the omena drying business to omena consumption was not mirrored in the Nile perch and tilapia value-chain. Participation in fishing was unrelated to feeling food secure and having a nutritionally adequate diet: fishing neither increased income for food purchasing nor directly improved fish provisioning for their households (as on the Kenyan coast, Kamau-Mbuthia et al., 2023). Actually, respondents in a household where one or more of the family members participated in the Nile perch or tilapia value-chain were less likely to be able to afford food. Children in Mombasa also had worse dietary diversity if they were part of a fishing household (Kamau-Mbuthia et al., 2023). Fiorella et al., (2014) also found that fish consumption was unrelated

to participation in fishing; instead, access to fish was related to wealth, as also found in Tanzania (Moreau & Garaway, 2018). Because Fiorella et al., (2014) did not take a value-chain approach or disaggregate between fish and omena, the correlation between participation in the omena drying business and omena consumption may have been missed. Indeed, recognising the smallholder fisheries actors' diversity is important (Short et al., 2021). Similar results were found in the Niger Delta region of Nigeria, where being a farming or fishing household was not predictive of food insecurity; rather, income, household size, farm size, remittances, and non-farm income generating activities were predictive of food security (Onyenekwe et al., 2022). The different findings between fish and omena may be a result of declining CPUE and increasing unreliability of fishing. It may also be a result of gendered roles within the fish and omena value-chain, where men dominate the entire fish value-chain whereas women dominate the omena processing. Other studies found that women are more likely to retain a portion of their fish for household consumption and redirect more of their income to household food security (Geheb et al., 2008).

7.3.7 Satisfaction levels with omena consumption

Poorer people were relying on omena to such a degree and with such a frequency that they wanted to eat less and have more variety in their diet. People who foraged were also more likely want less omena, likely for the same reasons: people who forage are poor and may be unlikely to afford an array of ASF besides omena). Indeed, feeling a lack of food choices was a key theme that arose from the qualitative work in the study area. **Feeling a lack of choices might also drive feelings of food insecurity, despite achieving the minimal diversity for a nutritionally adequate diet** (albeit heavily reliant on omena and indigenous green vegetables). Respondents with a higher fraction of children were also likely to want less omena, perhaps for similar reasons: omena may be more frequently chosen by parents with several children to feed due to its portionability and its ease of consumption. Its small bones mean can be eaten whole, whereas tilapia's flesh must be picked off before being fed to the child. This has implications for nutrition impact: omena consumption likely leads to higher calcium intake than larger fish consumption (Bogard et al., 2017).

In contrast, respondents in a household where no family members participated in the fish or omena value-chain were less likely to "want less omena". Compared to those working in the fisheries and omena value-chains, non-fisheries income-generating activities may result in less access to omena and a lower consumption frequency. **Wealthier people also wanted to eat more omena.** While wealthier people (specifically, those that had savings, owned land, and/or participated in table banking) felt more food secure and were less likely to eat omena, they expressed a desire to eat more omena. This is likely due to an increasing awareness of its micronutrient richness and perceived health benefits but lacked high-quality, cleanly processed omena (explained by key informants).

7.3.8 Nutrient intake at dinner

In contrast to the suggestion that the population had too poor dietary diversity for nutritional adequacy (a low MDD-S), overall, dinner was a rich source of many nutrients. **As the main meal, dinner provided over 100% of the RNI for carbohydrates, protein, selenium, Vitamin A, and Vitamin B12 on average.** Diets were also high in fats. Thus, the current diet is likely adequate for providing the RNI for these nutrients, which contrasts with other studies in the area which were based on a seven-day frequency score (Ohiokpehai et al., 2007). Pairing animal source foods with plant-based foods improves the bioavailability of the nutrients in the plant-based foods (Toure et al., 2003; Kawarazuka & Béné, 2011).

Dinners also provided most of the RNI for energy and iron. The risk of energy deficiency is likely low considering that other unaccounted foods are likely contributing calories. Furthermore, despite that almost 30% of households had a family member that did not eat, sufficient food quantities were always available, and reason for not eating were unrelated to the availability of food. Additionally, the satisfaction that people expressed around dinner suggested that these families were not lacking in energy. Almost everyone ate as much as they wanted. However, the risk of iron deficiency is unknown: at dinner, iron is mainly being supplied through ugali, omena, kales, tilapia, and beef. Since poorer people skipped meals, subsisted on ‘uji’ porridge throughout the day, and had low access to animal-source foods generally, they may lack sufficient iron intake.

In contrast, **the main meal was a minor source of zinc and calcium:** dinner provided less than 1% of the RNI for zinc and calcium. As dinner is the main meal, a higher intake of nutrients would be expected and thus the population’s diet may be deficient in zinc and calcium. It is unlikely that other meals (e.g., maize-based uji, mandazi, etc) are supplying zinc and calcium because they use similar ingredients to the foods listed at dinner. However, a complete daily record would be ideal to better understand a risk for deficiencies. Calcium-rich kales and leafy-green vegetables are not eaten in sufficient quantities to supply the recommended nutrient intakes. Because omena and fulu are affordable and high in calcium and zinc, increased portions of omena and/or fulu at dinnertime might improve the calcium contribution of dinner. Because small fish consumption in main meals is low as a relish, novel fish-based snack foods outside of main meals could improve calcium intake, like for example, fish wafers in Cambodia (Sigh et al., 2018). Wafers and snack foods enable higher intake of fish than when used as a relish in a main meal (Sigh et al., 2018).

7.3.9 Key foods for nutrient provisioning

In terms of nutrient provisioning, **ugali was the most important food across many nutrients.** A meal was particularly nutritious when ugali was paired with tilapia, omena, fulu, beef, apoth, and/or kales. Ugali was the main contributor of all measured nutrients except calcium, Vitamin A, and Vitamin B12. This was due to the large quantities of ugali consumed, with comparatively smaller

portions of other dishes, used as relish or sauce, as demonstrated by key informants. Maize also dominates diets in Eastern Kenya (Salfield et al., 1992; Tanzania (Ochieng et al., 2017) and Malawi (Donovan & Gelli, 2019). Tea was also within the top ten sources of carbohydrates due to the large quantities of sugar added to tea; indeed, other studies have shown significant sugary tea consumption (Global Diet Quality Project, 2021) and the diabetes pandemic in Kenya is worsening (Global Nutrition Report, 2021). While eggs were largely absent from dinners, **omena, fulu, kales, beef, and tilapia were important sources of nutrition**, despite being consumed in smaller quantities. Omena, fulu, and mumi (catfish) were affordable and thus more frequently consumed by the poor than the wealthy. While farmed tilapia is commonly consumed, it is limited to wealthier local consumers, in contrast to findings by Belton et al., (2018), which did not consider the SSA context. Farmed tilapia was consumed more frequently by wealthier people due to its higher price and chosen mainly as a substitute for wild tilapia when it was unavailable. Pond tilapia was rarely consumed: key informants remarked that pond tilapia did not taste ‘sweet’.

Omena and fulu were important for micronutrient intake as the main contributors of a calcium, a nutrient that may be deficient in the diet, as well as an array of other nutrients,. Wessels et al., (2023) also found that omena was micronutrient rich and suggested that it is an underutilised resource for supporting food security. For instance, although tilapia has a higher concentration of fatty acids than omena (wild tilapia is significantly leaner than farmed tilapia), omena has higher concentrations of EPA (Robert et al., 2014). Yet, the importance of tilapia may be overlooked: the relative importance of tilapia dishes, particularly for worse-off people for energy, protein, zinc, iron, calcium, and Vitamin B12 in these results is notable. The widespread consumption of tilapia, omena, and fulu may explain the lower malnutrition rates found by Geheb et al. (2008) on the Kenyan shores of Lake Victoria compared to inland communities and other communities around the Lake. Among Lake Victoria’s lakeshore communities, malnutrition rates in Kenya are lower than the national average; in contrast, those in Uganda and Tanzania are higher than the national average (Geheb et al., 2008). Ugandan lakeshore populations were sufficient in energy and protein, but deficient in calcium, iron, zinc, Vitamin A, and Vitamin B12 (Marivoet et al., 2022). This implicates the existence of some critical factor differentiating the nutritional status of Kenyan compared to Ugandan and Tanzanian lakeshore communities; comparative studies between areas around the lake are recommended to identify what factors create these nutritional inequalities.

7.3.10 Gendered, generational, and economic differences in nutritional intake

Differences in wealth were mainly apparent in carbohydrate, calcium, and Vitamin B12 sources, where people chose foods that they could afford. Better off people sourced carbohydrates from rice and ugali, whereas worse-off people relied on ugali. **For calcium, omena, fulu, and kale were the most important sources; however, worse-off people also consumed more calcium from tilapia.** This may be because poorer people were more likely to eat smaller, more affordable tilapia (Kaminski et al., in prep). Better-off people were likely eating larger tilapia, where larger bones that

are more easily removed. Better-off people had higher Vitamin B12 intake at dinner because they had greater access to ASF, which are commonly known as the predominant source of Vitamin B12.

In contrast, **differences in nutrient intake between household members were mainly due to the different quantities consumed**, as all household members would eat from a common pot. In every household, the mother/wife would prepare two or three dishes – normally ugali (sometimes rice), a vegetable, and/or an ASF – which would be served on each plate. While household members ate the same types of carbohydrate and zinc sources, the carbohydrate and zinc quantities varied likely due to different quantities of the dishes consumed. For iron, household members generally consumed the same quantities as each other and from the same dishes; however, **females have higher RNI for iron and thus consumed significantly less of their RNI**. Indeed, Kenya has failed to progress towards lowering anaemia (Global Nutrition Report, 2021). Thus, women and female children should be consuming larger quantities of iron-rich foods than their male counterparts. To increase their iron intake using readily available foods, women could consume larger portions of chicken, or alternatively apoth (an indigenous leafy green vegetable), which is cheaper.

Notably, all eta-squared values were quite low (<40%), a reminder that food choices are multi-factorial and wealth, age, and gender are only a few of many factors that influence what people eat.

7.3.11 Limitations

While academic and national data was not found, this study's sample had only 32.4% of households engaged in fishing. This seems surprisingly low considering the literature's description of mass migration to the lakeshores for fishing and key informant estimates that 70-90% of families receive direct income from fishing. This low figure may be due to our sampling method, where we recruited participants from major roads (fishing household may spend more time on the beach and may be underrepresented on the main roads). This low figure could also indicate that participation in fishing has actually become increasingly abandoned after the Nile perch decline, though this is unlikely considering that the number of fishers increased well after the Nile perch bust, increasing from 129,305 in year 2000 to 219,919 in 2016 (though we were unable to source more recent data on fisher populations; LVFO of unknown date). Regardless, opportunities to improve data availability and transparency are available.

Several additional limitations of this study provide opportunities for future research. First, due to time limitations, the fish consumption satisfaction level was not contextualised for respondent personality and their degree of optimism – i.e., some people are predisposed to feeling more or less satisfied generally, which may affect how they respond to their fish consumption satisfaction. Future studies should include additional questions around their overall life satisfaction would have allowed us to contextualise their answers (see methods by Serra-Mallola & Lebrund, 2023). Second, only three respondents had family members working at a fish farm and we were thus unable to compare

nutritional outcomes for fishers versus farmers. Subsequent research should use stratified sampling to examine these differences. Third, data on the source of fish was not requested in the 24-hour recall and the study relied on respondents' self-estimates of whether they sourced fish from fisheries or aquaculture. While future studies should request this information, consumers may not be aware of the fish source (Kaminski et al, in prep). Fourth, the 24-hour recalls incorporated quantities as well as types of food eaten in the past 24 hours; however, because people ate from a common pot of food, intake values for each ingredient were difficult for people to estimate. Indeed, 24-hour recalls are not appropriate for households that share from a pot of food (Dop et al., 1994) and respondents' quantity estimates can be inaccurate (Torheim et al., 2001), particularly for fish (Hemsworth et al., 2018). Instead, we used the 24-hour recall to generate an individual dietary diversity score. Future studies with more resources might consider using methods by Gomna and Rana (2007), who provided a kitchen scale and training that enabled research participants to record their own detailed food intake details in a food diary. Additionally, future studies should consider collecting three-day data, as other studies have found that three-day recalls are more likely to illuminate associations with complex outcomes than one-day recalls (Visser et al., 2021). Fifth, a major limitation of the MDD-W is that it treats foods equally, regardless of their nutrient density. An improved dietary diversity score would involve weighing foods to calculate their nutrient densities, as done by Katz et al., (2010). As Katz et al., (2010)'s weighting was based on a standard United States diet and did not include all the foods described in the present study (in particular, omena), their weighted scoring was not applicable and resource constraints prevented us from developing weighted scorings for the western Kenyan context. A scoring system like MARS (e.g., Patrick & Yoder, 1971; Lepicard et al., 2017; Beydoun et al., 2018; Akter et al., 2021) was likewise not applicable as the diets were recorded at the household rather than the individual level. Because this study was carried out at the household level and intrahousehold differences in consumption may exist, this study is insufficient to measure food security; food security is defined as "when all people, at all times, have physical and economic access to sufficient safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life" (FAO, 1996). Additional research examining intra-household differences in food security is warranted.

7.4 Summary: state of food security and the direct role of fishes in diets

This study adds to the 110 studies globally that have measured fish and seafood intake at the individual level (Casey et al., 2024). To answer the main research question, "What is the role of fish in fishing communities' food security on the Kenyan shores of Lake Victoria?", we had to first understand the current state of food security in the study area. This study discovered that several indicators show that food security in the study area was poor. Feelings of limited food security, low dietary diversity, and a meagre ability to afford a diverse diet were common. The population relied on cereals, oils, and sweets and this reliance threatens to create 'hidden hungers', where diets are calorie sufficient but lacking in key nutrients. While providing the largest contributions to many

nutrients, nutrients in ugali (maize) and other grains may not have been readily absorbed (i.e., low bioavailability), further masking potential micronutrient deficiencies (Gibson et al., 2006). Based on these indicators, we might conclude that almost half of the population was experiencing severe food insecurity and over two thirds had dietary diversity below the minimum required for a nutritionally adequate diet.

Yet, examining micronutrient intakes suggested that diets were indeed nutritionally adequate. Monotonous but nutritionally adequate diets were characterised by a heavy reliance on maize, fish, omena, and indigenous vegetables, all locally sourced (see also Korira & Tuitok, 2023). This reliance works because maize is well-known as a highly adaptive and tolerant crop. Dependency on fish has evolved as a consequence of fishery over-exploitation, leading to reduced levels of money, but paradoxically high levels of affordable nutrition (omena). While this dietary pattern is adequate for nutritional intake (apart from perhaps calcium and zinc because despite that omena is rich in zinc and calcium, portion sizes were too small to fulfil the recommended nutrient intakes – also seen in Cambodia by Singh et al., 2018), the overreliance on few key foods leaves them non-resilient to shocks in the food chain (e.g., maize disease). Significant public health repercussions can result; for example, Irish overreliance on potatoes led to mass famine and mortalities from a potato fungus *phytophthora infestans*. Due to colonialism and Catholic values against gluttony, Ireland failed to develop a unique food culture with a diversity of ingredients, and instead became dependent on introduced potatoes pre-famine (Armstrong, 2015). Post-famine, international development-driven food system diversified agricultural production and introduced international foods (Armstrong, 2015). Like Ireland, the Sindo area needs to improve the resilience of the diet through improved diversity. This can be achieved through increased agrobiodiversity (as in Ireland; Armstrong, 2015), better incomes and access to foods grown outside the study area.

Results indicated a shift in fish consumption patterns. People previously consuming a wide range of haplochromids now consume predominately one species: omena. Particularly with a limited range of fishing gear coupled with seasonality, drying is a critical food preservation strategy globally for ensuring access to fish during lean periods and farther from waterbodies and primarily done by women (Doe & Olley, 2020; Gupta et al., 2020; Lin, 2023; Reza, 2024). But in Sindo, consumers did not buy omena for storage: people bought enough omena to eat on that day. They preferred dried over fresh omena because they felt accustomed to cooking with dried fish, likely traditional recipes from when people ate dried haplochromids. Omena dryers had limited options for storing large volumes. Therefore, drying as a preservation strategy seemed to be geared towards stabilising omena for its transport to feed mills.

Food security appears to have worsened in the study area in the last 20 to 30 years, partly due to increasing commoditisation of the food system as local agricultural and fisheries food production diversity decreased. Cassava, millet, and sorghum are being replaced for maize, while a rich

diversity of fishes has been replaced with Nile perch, Nile tilapia, and omena. Nile tilapia aquaculture is likely to contribute towards this trend. Regional specialisation in food crop commodities targeting larger, regional or even international markets and its effect on local consumption patterns is a global trend (Rundgren, 2016). Simultaneously, the need to purchase imported foods for a diverse diet has increased, which is also a global trend (Rundgren, 2016). But in this study area, the population's ability to generate income for food purchasing was limited. Thus, with the decrease in locally available products and limited cash, people's food security worsened. Jeopardised food security as a result of low agro-biodiversity in this area is also alarming (Conelly & Chaiken, 2010). Smallholder producers are generally unable to afford intensification required to compete with global producers and their crop production becomes a liability rather than an asset (Rundgren, 2016). In this way, food has become a valued tradeable commodity with a price while people struggle to nourish themselves. Because fish have likewise been commoditised, income is also critical to accessing fish. As a result, a range of fish species and indeed most animal source foods are unaffordable to the poor. Yet, animal source food is critical for dietary diversity that translates to improved nutrient intake (Ruel, 2003).

The poor were a nutritionally vulnerable demographic. Differences in food security existed between economic classes, mainly concerning choice, food agency, and experiences of food security. In essence, worse-off people felt more food insecure and experienced the consequences of food insecurity more acutely than better-off people. Worse-off people struggled throughout the day, subsisting on porridge, tea, or skipping meal entirely. Instead, they were heavily reliant on their main meal (dinner) to provide nutrients: carbohydrate, calcium, and Vitamin B12 intakes at dinner were higher for worse-off people than better-off people. Globally, worse-off people may skip breakfast and consume larger dinners as a result of time-intensive and demanding labour, and this food intake timing can negatively affect health outcomes (Dashti et al., 2019). Interestingly, wealth was not correlated with dietary diversity because both better and worse-off people had diets highly reliant on the same food groups. Better-off people were eating different foods within the same food groups as worse-off people, resulting in similar dietary diversity. For instance, better-off people ate cabbage & fish while worse-off people ate indigenous greens and omena – in both cases, fulfilling two food groups of the dietary diversity score. Nevertheless, better-off people were able to utilise their assets (e.g., use their land for crop production) for income-generation that did support their food security.

For the poor, micronutritional deliverance came through omena: a small, low-value pelagic fish with disproportionate importance in worse-off diets with low diversity. Apart from ugali, omena (and to a lesser extent, beef, kales, and tilapia) played a prominent role in nutrient provisioning for both the better- and worse-off. For those around the lake and involved in the omena value-chain, their diets relied heavily on ugali and omena in the absence of other foods. Omena, as an affordable food that is rich in zinc and calcium, is particularly important considering that the main meals were deficient in these nutrients. As a small pelagic fish that is eaten whole, omena is indeed a nutritional powerhouse (Kolding et al., 2019; Wessels et al., 2023). Nutrients in animal source foods are well

known to be more bioavailable than plant-based sources. The bioavailability of certain nutrients in small fish especially, and their role in nutrient provisioning of the poor have been highlighted (Hansen et al., 1998; Kawarazuka & Béné, 2011; Isaacs, 2016; Byrd, 2021). In this study area, cultured tilapia has not become a food for the poor as in Bangladesh and elsewhere in Asia (Little, 2000; Belton et al., 2014); this may be because wild fisheries still provide affordable omena and tilapias at the same price as the tilapia farms and the economic incentive to purchase farmed tilapia is not yet as developed as in Asia.

However, wellbeing is not limited to nutritional intake. Wellbeing is also tied to subjective experiences of food (Grunert et al., 2007; Schnettler et al., 2015; Meiselman, 2016), which is often ignored in nutritional assessments and food security discussions. Overconsumption of omena, its shameful association with poverty, and a lack of food agency has incited negative subjective experiences for poor people in the study area. Some of the poor were so dependent on omena (resulting from an inability to afford other foods) that their enjoyment of food suffered. Like the Irish with potatoes and the Italians with polenta (Armstrong, 2015), omena was a staple food associated with poverty. Indeed, the poor in the present study desired more diverse ‘balanced’ diets and food variety. Improving economic activity, income-generation capacity, and people’s ability to purchase a wider variety of foods would likely result in more diverse diets and better welfare experiences.

Despite accounts that the poor only ate omena, many people still ate tilapias and Nile perch. Key informant accounts of being only able to afford omena conflicted with images of children carrying an abundance of fish and nutrition data showing reasonable monthly consumption rates of Nile Perch and tilapia alongside omena, even for the poor. Children sourcing these fish may explain this contradiction: indeed, poorer people are unable to afford fish, but are still able to access it through children’s fishing activities. This may be a form of ‘hidden harvest’ (Fluet-Chouinard et al., 2018). They may overlook children’s contribution or avoid sharing more information because children often fish in illegal breeding areas. Fishing was a fun activity for children and might contribute significantly to household subsistence, although to what extent fish sourced from children explains this contradiction – i.e., people saying they can only afford omena but also reporting monthly consumption of Nile perch and tilapias – is unknown.

While the poor desired less omena, the rich desired more omena. The increasing desire for omena among the wealthy indicated that omena may be on the cusp of gentrification, and the demand for ‘clean’ and higher quality omena product may increase. Increasing demand among wealthier consumers could result in price increase. This might reduce the affordability of omena for poorer consumers; on the other hand, it may provide opportunities for omena dryers to improve the profitability of their business. Regardless, large tilapia and Nile perch were associated with a higher social status than omena, despite that these small fish were more nutrient dense and also made significant contributions to the recommended nutrient intakes. People wanting trendier, but less

nutritious fish, was also occurring with local vegetables. People shunned foraging, but local vegetables might be more nutritious than imported ones. Food preferences – for more modern vegetables that are less micronutrient-dense than traditional vegetables that are associated with lower status – undermine food security among the Kenyan Luos (Ogoye-Ndegwa & Aagaard-Hansen, 2003). For instance, sukumawiki (an indigenous leafy green vegetable) has a superior status than indigenous leafy green vegetables and is consumed abundantly by most people (Ogoye-Ndegwa & Aagaard-Hansen, 2003). Traditional food consumption is associated with poverty, and meat consumption is associated with wealth and socio-economic status (Owino, 2019).

While food security was affected by wealth, it was not affected by gender. Access to food did not seem to be gendered, since dietary differences at the individual level within a household were minor (section 6.2.4); however, it is likely these results are limited to better-off demographics. Gendered differences in micronutrient intake in Eastern Kenya have been documented by other authors (Ndiku et al., 2011). Furthermore, there may be differences between polygamous and monogamous households: children in polygamous households in Mombasa were more likely to be underweight than children in monogamous households (Kamau-Mbuthia et al., 2023). This would be worth repeating with more resources by randomly selecting households and following family members for a day to track their food intake or train them to use diet diaries.

Children may be a particularly nutritionally vulnerable group. Children ate significantly less carbohydrates, zinc, iron, and vitamin A than adults at the main meal; whether the rest of their daily diet supplies these key nutrients is unknown and worth additional research. Additionally, orphan prevalence and their associated ‘burden’ on the household negatively affects food security experiences; as this thesis did not examine the effect of orphans on household dietary diversity or nutrient intake, further research is recommended.

Several additional limitations of the household questionnaire provide opportunities for future research:

1. Due to time limitations, the fish consumption satisfaction level was not contextualised for respondent personality and their degree of optimism – i.e., some people are predisposed to feeling more or less satisfied generally, which may affect how they respond to their fish consumption satisfaction. Future studies should include additional questions around their overall life satisfaction would have allowed us to contextualise their answers (see methods by Serra-Mallola & Lebrund, 2023).
2. Only three respondents had family members working at a fish farm and we were thus unable to compare nutritional outcomes for fishers versus farmers. Subsequent research should use stratified sampling to examine these differences.
3. Data on the source of fish was not requested in the 24-hour recall and the study relied on respondents’ self-estimates of whether they sourced fish from fisheries or aquaculture. While

future studies should request this information, consumers may not be aware of the fish source (Kaminski et al, in prep).

4. The 24-hour recalls incorporated quantities as well as types of food eaten in the past 24 hours; however, because people ate from a common pot of food, intake values for each ingredient were difficult for people to estimate. Indeed, 24-hour recalls are not appropriate for households that share from a pot of food (Dop et al., 1994) and respondents' quantity estimates can be inaccurate (Torheim et al., 2001), particularly for fish (Hemsworth et al., 2018). Instead, we used the 24-hour recall to generate an individual dietary diversity score. Future studies with more resources might consider using methods by Gomna and Rana (2007), who provided a kitchen scale and training that enabled research participants to record their own detailed food intake details in a food diary. Additionally, future studies should consider collecting three-day data, as other studies have found that three-day recalls are more likely to illuminate associations with complex outcomes than one-day recalls (Visser et al., 2021).
5. While academic and national data was not found, this study's sample had only 32.4% of households engaged in fishing. This seems surprisingly low considering the literature's description of mass migration to the lakeshores for fishing. This low figure may be due to our sampling method, where we recruited participants from major roads (fishing household may spend more time on the beach and may be underrepresented on the main roads). This low figure could also indicate that participation in fishing has actually become increasingly abandoned after the Nile perch decline, though this is unlikely considering that the number of fishers increased well after the Nile perch bust, increasing from 129,305 in year 2000 to 219,919 in 2016 (though we were unable to source more recent data on fisher populations; LVFO of unknown date). Regardless, opportunities to improve data availability and transparency are available.
6. This study area was known to eat fish frequently and throughout the year; thus their consumption could be captured within a 24-hour recall. Regardless, single 24-hour recalls do not capture seasonality may underestimate fish consumption (Casey et al., 2024). Ideally, recalls would have been repeated monthly over the entire year to understand seasonality of fish consumption.

From the dinner intake study, four major limitations were identified:

1. Selection methods were not random and may have introduced bias, as people from a social network might share food practices and may not be representative of the population. Ideally, data would have been collected from a randomised and much larger group of households from the study area. This would require significant resources. Providing kitchen scales and training respondents to record their own food may be a more efficient way to collect larger quantities of data; however, this may place a greater burden on participants.

2. Dishes may have been instinctively altered from the “norm” due to the enumerator’s presence. While sharing food and preparing special food is common when visitors are present, the households were requested to not include the enumerator in their meal plans and to cook as if they were preparing a normal dinner for the family. However, it is unfeasible to ensure that households complied with this request. Enumerators understood the importance of complying and not accepting dinner from the family to avoid reducing serving portions.
3. Understanding micronutrient intake as a percentage of the recommended nutrient intake requires a complete record of dietary intake over at least 24 hours, although ideally over multiple days to account for day-to-day variation (Bailey, 2021). Due to resource limitations, it was unfeasible for an enumerator to track a person’s intake throughout the course of one to three days, and thus dinner was selected because it was the main meal of the day and would enable a larger dataset since households typically ate dinner together (other meals were typically consumed separately). As identified in the 24-hour recall surveys, food diaries were also unfeasible because people struggled to measure each food they consumed, let alone the amount of each ingredient consumed.
4. The dataset itself was small. Thus, statistical comparison between foods in terms of their nutrient contribution would have lacked statistical power and only a descriptive analysis was used. The dataset included only one egg consumer (a male adult). Additionally, children were underrepresented as the dataset compared to adults.

Future research should consider several angles excluded from this research. Firstly, differences in nutrient-intake between male- and female-headed households should be compared. The gender of the household head has been observed to influence ASF consumption: while male-headed households had improved dietary diversity resulting from higher income, female-headed households prioritised consumption over sales of market and household-sourced eggs and chicken (Musyoka et al., 2023). In the present study, the aim was to rule out differences between family members, and thus the presence of both a male and female adult was an inclusion criterion. A study aiming to understand differences between male- and female-headed households should use a stratified sampling approach. Because this research has shown very few gendered or intergenerational differences in nutrient intake, future studies should direct resources towards collecting a full day’s worth of quantitative food intake data using one person per household to understand if nutrients deficient in dinner may be supplied through other meals.

Chapter 8: Local perceptions of the emergent aquaculture-fisheries continuum in Kenya's Lake Victoria

8.1 Methods

The methods used qualitative and quantitative research methods: interviews, focus groups, and a household questionnaire. The design and sampling of these tools were described in sections 5 and 7.1. Three main sections of the household questionnaire were used in this analysis:

1. **Demographics:** An initial section asked respondents about each of their household members, their gender, age, education level, and main occupation.
2. **Fish consumption habits:** This section asked about the households' fish consumption habits, where they usually sourced their fish, where they preferred to source their fish, and what types of fish were the most affordable and easiest to find.
3. **Opinion statements:** This questionnaire also included several Likert-scale questions. A Likert-scale rating system was used as a validation approach, quantifying to what degree the wider community agreed with several opinions statements generated during the interviews and focus groups. The opinion statements were generated through in vivo coding from the aforementioned activities and were chosen because they were repeated throughout several interviews/focus groups.

Data were collected between January through April 2023 using a mobile application designed for remote data collection (Lakshminarasimhappa, 2022). After data collection was complete, written data were imported and mobile application data were exported to Microsoft Excel (Microsoft Corporation, 2018) and all data management and analysis were conducted in Rstudio (R Core Team, 2020). Linear regressions were used to examine correlations between wealth and responses to opinion statements (i.e., the Likert-scale questions).

8.2 Results

This section discusses themes arising from inductive analysis of the qualitative work and select data from the household questionnaire regarding fish acquisition and consumption (Table 1) and likert-scale responses to opinion statements generated from the qualitative analysis.

8.2.1 Quantitative results

As mentioned previously, the enumerators obtained data from 259 households for the interhousehold questionnaire. The results of fish consumption preferences and habits are shown in Table 19. The results of the Likert-scale opinion statements are shown in Figure 36.

Table 19: A descriptive summary of the survey responses from the interhousehold questionnaire.

Percent of respondents who consume	Now	As a child
Omena	98.8% (n=256 of 259)	90.3% (n=234 of 259)
Wild tilapia	79.5% (n=206 of 256)	66.8% (n=173 of 259)
Nile perch	77.2% (n=200 of 256)	62.2% (n=161 of 259)
Farmed tilapia	52.9% (n=137 of 256)	5.79% (n=15 of 259)
Catfish	31.3% (n=81 of 256)	19.3% (n=50 of 259)
Pond tilapia	6.95% (n=18 of 256)	1.54% (n=4 of 259)
Other fish	49.0% (n=127 of 256)	37.8% (n=98 of 259)
Acquiring fish	Easiest fish to find	Most affordable fish
Wild tilapia	33.2% (n=85 of 256)	21.5% (n=55 of 256)
Nile perch	31.3% (n=80 of 256)	32.4% (n=83 of 256)
Farmed tilapia	10.5% (n=27 of 256)	10.9% (n=28 of 256)
Catfish	1.17% (n=3 of 256)	1.56% (n=4 of 256)
Tilapia vendor	Normal	Preferred
Market	53.1% (n=136 of 256)	34.0% (n=87 of 256)
Lake	20.7% (n=53 of 256)	21.5% (n=55 of 256)
Fisher	10.5% (n=27 of 256)	14.1% (n=36 of 256)
Branch	7.81% (n=20 of 256)	8.59% (n=22 of 256)
Hotel	1.56% (n=4 of 256)	6.25% (n=16 of 256)
Banda	0.781% (n=2 of 256)	3.13% (n=8 of 256)
Tilapia vendor reason	Normal	Preferred
Availability	32.0% (n=82 of 256)	6.64% (n=17 of 256)
Cheap	13.3% (n=34 of 256)	12.5% (n=32 of 256)
Fresh	20.3% (n=52 of 256)	52.0% (n=133 of 256)
Proximity	0% (n=0 of 256)	3.91% (n=10 of 256)
Other	21.9% (n=56 of 256)	26.2% (n=67 of 256)



Figure 36: The degree to which participants agreed with the following statements from key informant interviews and focus groups, using a Likert scale.

8.2.1 Qualitative Results

“Fisheries are failing.”

Like other foods, fish commoditisation has occurred in the last twenty to thirty years. Where fish were previously viewed as food and gifted regularly, fish were now perceived as cash. Most people (82%) generally agreed that fish was no longer gifted (Figure 1). Recent commoditisation of fish was also mentioned by Luo respondents in Siaya district (Nyambedha et al., 2003) and Uganda (Beuving, 2010). Sanon et al., (2021) also argued that commodification of fish has occurred, where fishing has shifted away from subsistence to commercial orientation (Sanon et al., 2021).

A fisherman who goes fishing, they do not intend to eat the Nile perch that they caught. (Male fisheries governance representative)

This was attributed to fish commoditisation as well as a shift in the distribution of small to large scale fishers. Independent fishers may have been inclined to retain even a small portion of their catch for home consumption; these fishers have increasingly been replaced with large-scale fishing businesses that instead employ fishers and retain ownership of the fish catch: “Fishers no longer work for themselves” (fisheries governance representative). These large-scale fishing businesses have vertically-integrated operations for fish. Key informants explained that these large-scale fishing businesses were often owned by Somalian immigrants or wealthy Indian Kenyans from outside the study area. Thus, key informants perceived these business owners as “strangers” entering their value-chain.

The fisheries value-chain showed evidence of consolidation. Respondents concurred that the Nile perch and tilapia value chains were increasingly characterised by large integrated businesses and decreasingly by smallholder operations. Over time, the fishers themselves owned fewer physical assets (e.g., boats) and have become increasingly reliant on environmental resources for income-generation. This may have put their livelihoods at risk, as they would have fewer alternative sources of capital at their disposal in times of crisis. Furthermore, integrated businesses tended to aggregate and export fish from the study area, such that fish mainly contributed indirectly to food security through income generation. Fish for direct consumption were mainly sourced from bandas, markets or through subsistence fishing off the beach by women and children.

The introduction of ‘strangers’ controlling the fishing trade jarred against the strong local ethnic identification with fishing. Luo ethnic culture – a politically described and self-proclaimed form of local identity – particularly was associated with fish eating and fishing, also recognized by Ogoye-Ndegwa & Aagaard-Hansen (2006) and Volpato & Ellena (2023). BMU members estimated that 95% of the population was Luo and/or originally from the lakeshores, while 5% were from other areas of Kenya, contradicting literature descriptions of mass migration to the lakeshore. Fishing technologies and skills were transferred generationally from elder to younger men, both inter and

intra households. As one elder affirmed, “we were taught how, when, what, and where to fish.” Young children fished at the lakeshore with a pole and line as “a childhood hobby”, graduating to working with nets from shore and eventually with nets on boats. Some fishers were taught to pray prior to fishing. Regarding Uganda, young men without familiar ties to fishers might gain access to a fishing crew by first offering portering services, e.g., running errands or sourcing substances for the crew (Beuving, 2010). Ugandan boat crews often became friends and identification with a crew was socially important (Beuving, 2010).

Alongside the strong ethnic affiliation with fishing found in the present study, a high level of risk was associated with fishing. Key informants compared Lake Victoria to a “gold mine”, where fishers could labour without rewards or come back with their pockets overflowing with money. This high reward potential for fishers created societal conflicts. For instance, ongoing societal challenges with alcoholism was brought up in many conversations. On days with high catch, many fishers would spend cash on alcohol, prostitutes, and gambling, as documented elsewhere and associated with increased prevalence of HIV/AIDS compared to non-fishing communities (Allison & Seeley, 2004; Malenganisho et al., 2007; Ngwenya & Mosepele, 2007; Beuving, 2010; Kwena et al., 2010; Asiki et al., 2011; Stabinski et al., 2011; Seeley et al., 2012; Tumwesigye et al., 2012; Ssetaala et al., 2015; Sileo et al., 2016; Kiwanuka et al., 2017; Breuer et al., 2019; Kiene et al., 2019a; Kiene et al., 2019b; Kuteesa et al., 2020; Kwiringira et al., 2019; Musumari et al., 2021). Van der Knapp and Ligtvoet (2010) referred to this dynamic as “expenditure patterns of fishermen dealing with relatively large sums of money without saving and investment possibilities”. This lifestyle was preferred by fishers, leading then to persist in the industry despite its high risk nature (Beuving, 2010). Fishers’ rambunctious behaviour paired with the community’s reliance on them for provisioning of culturally important and affordable animal source food created a double-bind: while fishers were powerful and could be (depending on the day) some of the most resourced individuals in the community, they were not respected due to their participation in debauchery. Some key informants even declared that beach areas as ‘upcoming slums’ due to the prevalence of and increasing addiction to these activities in light of declining income from fisheries. Perceptions of fishing as a profession varies by region. In certain areas of Burkina Faso, fishing was perceived as ‘lazy’, and only a few people occasionally fished for subsistence purposes only; in contrast, some ethnic groups self-identified as fishing experts (Sanon et al., 2021). In the Okavango Delta, subsistence fishing has socio-cultural value to female fishers, who pass down cultural knowledge about subsistence fishing through generations (Mmopelwa et al., 2009). In Namibia and Zambia, fish trading was historically seen as a livelihood for the poor; however, the commoditisation of fish increased profits and thus interest in fish trading and the degree of respect associated with the livelihood (Abbott et al., 2015).

When asked about the status of the fisheries resource, all key informants perceived that the fisheries resource was failing, likely confounding decreasing catch-per-unit-effort with productivity. Elders stressed the relative lack of biodiversity in fish catch. They listed a wide array of fish species that

were no longer available to them. Key informants explained that while Nile perch were plentiful, large Nile perch were rare. This species is now less of an export item and is now often traded and eaten locally. This was also found by Nyamweya et al. (2023). Furthermore, fishers felt forced to go farther and deeper into the lake to access the same catch as they used; however, this is likely due to decreased CPUE rather than decreased biomass (Nyamweya et al., 2023). Indeed, most people agreed that “fish catch is declining” (86%) and “More and more people are fishing from the lake” (87%) (Figure 27). One BMU representative who was also a fisher recounted that while he used to return from fishing with a full boat of omena, he now sometimes returns with a small fraction of that, or nothing at all. Fishing communities in Uganda also believed that decreasing catch-per-unit-effort (CPUE) was evidence of decreasing fisheries populations in the lake (Andrew et al., 2016). The unreliability and high risk/reward nature of the Nile perch fishery was also described in the Ugandan part of Lake Victoria over fifteen years ago (Beuving, 2010). In the absence of updated and reliable fisheries data on catch levels and numbers of fishers, fishery robustness is difficult to estimate. The fundamental resilience of these fisheries is largely unknown, despite the large proportion of literature on Lake Victoria’s ecology and Nile perch assessments. This should be a priority research area as a significant number of people around the lake are dependent on it.

Some saw the decline as a normal part of boom-and-bust cycles and were waiting for the fish to return; others feared the situation was dire and that alternative livelihoods were required. The politician believed that “the lake is in a full-blown crisis: virtually all species has declined, the biomass needs rescuing, and the future will be a period of attrition and uncertainty... [fishers] have not yet accepted the reality of wild catch in the lake.” The decline in catch was explicitly linked with worsening food security, since unpredictable cash from fisheries hampered cash flow within the community. Even table banking was perceived as dependent on the vibrancy of the fishing industry. Key informants believed that most lakeshore households were directly dependent on fisheries: some key informants estimated that 70-90% of families received direct income from fishing. However, this estimation is much greater than the 32% that was estimated by the household survey (Chapter 7) and the population may be less reliant on fisheries than perceived, although this requires additional research. This seems surprisingly low considering the literature’s description of mass migration to the lakeshores for fishing and key informant estimates that 70-90% of families receive direct income from fishing. This low figure may be due to our sampling method, where we recruited participants from major roads (fishing household may spend more time on the beach and may be underrepresented on the main roads). This low figure could also indicate that participation in fishing has actually become increasingly abandoned after the Nile perch decline, though this is unlikely considering that the number of fishers increased well after the Nile perch bust, increasing from 129,305 in year 2000 to 219,919 in 2016 (though we were unable to source more recent data on fisher populations; LVFO of unknown date)."

Worsening environmental conditions and an abundance of fishers were often cited as reasons for declining catch. Government representatives were clear that the “abuse of resources” was responsible for worsening environmental conditions in the lake. Key informants specifically listed overfishing, cutting down trees for firewood, and environmental degradation generally as key factors causing fisheries decline. In addition, fish farmers, BMU representatives, and Fisheries officers all expressed concern about poor policing and enforcement of regulations on the lake (Chapter 3). This was due to insufficient resources but also jurisdiction arrangements. While the BMU’s role was to encourage responsible fishing practices, communicate regulations to fishers, support marketing of fish products, and organise cooperatives, its jurisdiction was at the county level on the beaches and did not extend into the water. Government officials identified the Kenyan Government’s Kenya Marine Authority as responsible for implementing policy but noted resource limitations and other challenges of monitoring fishers in such a large waterbody.

Regardless, those engaged in the fisheries value-chain perceived that the fish and omena were “retreating” into the lake. Thus, they felt the need to go deeper into the lake to harvest satisfactory quantities of catch, despite life-threatening weather and water conditions and an inability to invest in equipment and boats suited for rougher waters. Fishers recognized the dangers of venturing into Ugandan waters, where they risked rougher conditions, corporal punishment and confiscated catch by Ugandan authorities for crossing the boundary. Additionally, fishers were aware of the environmental implications of violating fishing regulations and using illegal fishing gear, but explained, “but people are hungry” (BMU representative). Fishers perceived fishing as a critical activity, saying “we *have* to fish” (fisher in Sindo) and “we have no choice” (fisher in Sindo). They explained that the fish they caught was insufficient for the wider demand – even local demand was higher than the supply. In response to decreasing catch, some fishers were diversifying their income or switching professions entirely, venturing into bodaboda or other businesses. The area is in a transition period, where fish catch is still enough to generate a livelihood, but “people are beginning to appreciate the gravity of the situation [declining fisheries]” (fish farmer) and many fishers are diversifying their income in response. Despite this, there was no evidence of fishers exiting the fishing business, perhaps due to the establishment of new lives and kinship ties (Beuving, 2010; Sileo et al., 2016).

Key informants listed several shocks that they had experienced that affected their food security. These included: unpredictable rain patterns, droughts, torrential rains that sweep away crops, disease pandemics and outbreaks (cholera, HIV/AIDs, COVID19, typhoid, gastro-intestinal diseases, and an unidentified skin rash), livestock disease (chicken pigs, maize pests), poor fish catch, algal blooms, fish diseases that led to massive fish kills across the lake (the most recent was a disease outbreak of Nile perch in 2020 caused massive mortalities, floating around the lake), theft/vandalism of boats and nets, domestic abuse, and famines. A famine in Luo history was named *Log dichiel*, which translates to ‘wash your hands once’ for the rationed one meal per day (Ogoye-Ndegwa & Aagaard-

Hansen, 2006). Apart from famines, the study area experienced annual lean periods related to reduced fisheries catch and concomitant decreased cash circulation throughout the community. These lean periods had become more severe over time¹². Key informants varied in their responses about lean periods and seasonality. This might have been because of the wide seasonal variation between years, as one respondent said: “Seasons of hunger change every year.” They did agree that fishing catch was higher during the rains and lower during dry spells.

The COVID19 pandemic was also a shock on the community. Omena dryers noted that the omena business was more profitable before the COVID19 pandemic, because “the expenses are the same, but the profit is none.” This was explained by an omena dryer: “Omena was plenty during the pandemic, but no one to buy it.” Whereas omena drying used to be ‘a good business’ (as also found by Camlin et al., 2013), it was now a risky and unrewarding business. The disproportionate impact of the COVID19 pandemic on women’s livelihoods was also noted by Meru and Kinoti (2021). As those who cook and regularly access food stores, women are the first to recognise impending famines (Ogoye-Ndegwa & Aagaard-Hansen, 2006). Other respondents noted that the pandemic increased costs. Regardless people noted that they continued to work during the pandemic because they relied on their income for food security and school fees. Fiorella et al. (2021) found that lakeshore residents in Kenya reduced fishing activities for fear of contracting COVID19 and restriction on movements, and as a result of decreased income, relied on dried fish consumption. In Malawi, the COVID19 pandemic resulted in worsened food security for fishing-dependent households (Chiwaula et al., 2022).

The Nile perch boom led to high fishing pressure, the commoditisation of fish, consolidation of the fishing value-chain, and subsequent productivity decline – a classic example of fishing down the food chain (Pauley et al., 2000; Wilen & Wilen, 2012). Because the boom ended but fishing pressure continued, fishing as an occupation was less profitable and desirable as a profession. People no longer aspired to become fishers: fishing was increasingly risky and fishers were associated with crime, alcoholism, prostitution and gambling. On the other hand, people were still drawn to the fish-value chain due to ethnic affiliations and low barriers to entry (e.g., no education requirements and ability to join a crew without the need to own physical fishing assets). Some subsistence shore-based fishing continued, but with minimal impacts on food security, because most people still had to purchase fish for consumption. Ergo, while people were seeking alternative livelihoods, they still depended on fisheries as a back-up livelihood and to provision fish in markets for purchasing.

“Both fishing and cage farming are important.”

Considering the difficulties in the fishing industry, key informants tended to see benefits from emergent aquaculture (Figure 37). Firstly, key informants viewed aquaculture as a reliable and

¹² A significant limitation of this thesis was its exclusion of seasonality-related data.

profitable industry. For instance, both a BMU representative, an omena dryer, and a housewife said, “it is a good business.” The increasing unreliability of the fishing industry contrasted with the rapid expansion and profitability of local large-scale tilapia farms. Considering the perceived unreliability of fishing, cage farming was perceived as comparatively reliable. Because of this, fish farming was perceived to have fewer risks compared to fishing:

*If we go fishing, and then we might come with nothing if we don't catch anything.
But... that is a caged fish. It's there, automatically.* (BMU representative)



Figure 37: A large offshore commercial-scale tilapia cage owned by Victory Farms on Lake Victoria, supporting two fish feeders.

Aquaculture was perceived as complimentary, rather than a replacement for fishing. Key informants even used language inferring that they perceived fishing and aquaculture as the same industry: BMU representatives referred to fishing as “traditional fishing methods” and aquaculture as “modern fishing methods”. One representative said, “Cage culture [tilapia farming] embraces technology.” Some disdain was observed for traditional methods, as key informants used words like “rudimentary” or “stuck in traditional ways”. ‘Local’ fish as synonymous with ‘wild’ fish mirrored perceptions of the chicken industry, where local ‘kinyeji’ chickens that roamed the homesteads were clearly distinguished from imported ‘broiler’ chickens that were used for intensive meat and/or egg production. Like local and broiler chickens, both wild and farmed fish were perceived as important for food security: fishing could provision the community with fish for direct consumption, whereas

fish farms generated stable employment that improved income and cash flow within the community, enabling fish purchasing. Indeed, a BMU representative said, “both fishing and cage farming are important”.

Additionally, key informants considered aquaculture’s potential positive affect on fisheries and fishers. BMU members, fisheries representatives, and the politician all believed that developing the aquaculture industry would help relieve pressure on fisheries. They explained that offering fishers alternative livelihoods in the aquaculture industry would reduce the number of fishers on the lake. This would have the environmental benefit of reducing pressure on the fishery populations but would also lead to an increased catch per unit effort for remaining fishers. They envisioned that some boat owners could instead own their own fish farms, and fishers could be employed at fish farms. The farms were unable to estimate what percentage of their employees were fishers, although this statistic would be worth investigating.

BMUs understood that while large-scale cage culture operations required significant investment, pond farming was a more financially accessible alternative (Figure 38). Some key informants described that wealthier community members were experimenting with their own pond culture systems, inspired by the tilapia cage farm. This local small-scale pond culture development was encouraged by the tilapia cage farm, who provided technical and production knowledge support. The tilapia farm also occasionally supplied fingerlings for stocking pond farms or partnered with farmers to outsource egg production to pond farmers in an ‘out-grower’ programme. It was unclear if existing pond farms were all supported by the tilapia cage farm’s out-grower programme or if any independent ones existed. While the support was appreciated, BMUs noted that regulatory frameworks, funding, and training is also required to support local smallholder pond farmers. BMU members observed the success of local large-scale tilapia cage farms and small-scale pond farmers and had aspirations of their own. Tilapia farms were viewed favourably (and perhaps enviously?) as “a good business to do” due to its reliability and perceived profitability. Yet, the benefits of smallholder aquaculture development in Kenya will most likely benefit male-headed households and gendered considerations for development are recommended (Kaliba et al., 2007).



Figure 38: A fish farmer collects eggs from a tilapia broodstock.

Key informants saw opportunities to transition fishers to fish farmers, but they envisioned employing fishers at fish farms rather than enabling fishing to own fish farms themselves. Government officials understood the significant investment costs regarding cage and pond culture were inhibitive for most people. The aquaculture opportunity was inaccessible to locals generally due to the high capex requirements. Most residents had insufficient savings to invest in fish culture because they were living day to day and were unable to continue investing in their fish stock over the entire production period. Regarding investing in aquaculture, one key informant noted, “telling them to wait [for income] means telling them to fail.” The challenges of a sustained investment period before realising returns and lack of technical, organisational or institutional capacity for cage farming was also described in Malawi (Hara, 2011; Limuwa et al., 2018). The likelihood of transitioning fishers to fish farmers may also be inhibited by strong fisher identities and culture (O’Driscoll-Adam, 2014; Ross, 2015); a fisher accustomed to quick cash influxes and strong social bonds within his crew may be unwilling to invest in fish farming, a less social activity with longer return-on-investment periods.

Indeed, every conversation identified employment generation as a key benefit of the local tilapia farm. The wider community generally agreed that the tilapia cage farm created employment (Figure 27): As one key informant described,

Traditional fishing methods employ few, but [tilapia] cage farming employs many.
(Male Elder, littoral fishing village)

Boat owners were limited in how many fishers they could hire; in contrast, the potential employment offered by tilapia farms was much higher. It was noted that while fishing was exclusive to strong

young men, the fish farms employed a variety of people, including youths, older people, women, and even people without higher education degrees through the variety of roles involved in their vertically-integrated operation. For example, mainly women were employed in its processing plant. Indeed, employment generated by the tilapia farms was significant: all key informants had family members or friends who worked at the tilapia farm. The fish farm cited that they employed over 600 people from the local community and calculated that they affected the lives of 4000 that depended on the salaries of those employed. One respondent described that “people depend on people with jobs.”

In addition, employment at the tilapia farm supported the employee’s social status. Respected professions were public-facing and/or financially secure, such as leaders, pastors, chiefs, parliament, teachers, doctors, and most relevantly: employed people. While a few women farmers mentioned that Elders were respected (gerontocratic values persist across Africa generally; Muia et al., 2013), employment was emphasized as the basis of respect:

The rich are more respected. (Female youth)

Money is respect. (Male fisher)

If you have money, you will be more respected. (BMU representative)

Respected people have money, boats, jobs, a permanent house. (Politician)

Working in another town is more respected than working locally. (Middle-age woman in a littoral village)

The one who works at Victory Farms [the cage tilapia farm] is more rich than who struggles daily to get food. (Worse-off woman in a littoral village)

Working away was more respected because it indicated employment with a steady income. Professions that were not respected included housemaids, charcoal sellers, and cattle herders because these were “jobs for the poor”. One older woman interjected that “But charcoal selling will be respected [in the future], because there will be no jobs.” Despite that most fishers were employed, respect towards fishers varied between stakeholders. BMU members, fisheries officers, and elders remarked that fishers were respected, but omena dryers did not respect fishers:

There’s no other name which is bad like a fisherman. (Female omena dryer)

Fishing is not a profession... but we have to respect fishers because they give us omena. (Female omena dryer)

Previously, fishers had income and boats that were critical for transportation, so they were better placed socially... now, fishers are still respected, but depending on their conduct. (Politician)

The growing irregularity of fish catch and unreliability of fishing as a profession coupled with their tendency towards debauchery and improved road networks led to decreased social status for fishers. In contrast, employment at a fish farm was unanimously respected and highly desirable because it was reliable income without higher education requirements. The disreputability of omena dryers due to their association with the sex-for-fish trade as found by Camlin et al., (2013) was absent from this study (i.e., none of the key informants brought it up).

With pond farming and employment generation, the emergence of the fish farm stimulated other economic activity within the study area. The emergence of tilapia farms led to more money circulating in the village, which led to overall improvements in living standards and “lessening social discomfort”. A greater number of employed people led to increased and more regular local spending. Key informants claimed improved ability to borrow money from tilapia farm employees and more money available in table banking groups.. Additionally, migration into the area increased the need for rental housing and other auxiliary services (e.g., construction work, hair salons, restaurants), creating alternative income-generating businesses for residents. While most people agreed that fish farming was increasing migration into the area, elders noted that migration also created some social tensions as different types of people learned to live together.

Some key informants were relieved that certain fish farms had taken over space previously used to make illegal alcohol, resulting in less alcohol-related social conflicts in their village. Many people believed that fish farming had even reduced crime (Figure 36). The women who used to make the illegal alcohol were now employed at the tilapia farm. For this reason, paired with the generation of employment, many key informants felt that the emergence of tilapia farms reduced theft caused by alcoholism and idleness of unemployment, particularly of youths. The engagement of youths was a strong message that came out in many interviews and focus groups, through comments like “they employ the roaming youth” and “the youth have something constructive to do now.” Government officials believed that the tilapia farm and its employees provided “visual cues to locals that they can do better,” in terms of livelihood generation, living standards, and welfare. Their comments suggested that the fish farm could inspire hope and aspiration for some, while garnering jealousy, malice, and resentment for others.

Key informants also identified several key disadvantages of emergent aquaculture. For instance, the emergence of tilapia farms had increased tilapia prices, thus reducing its affordability and accessibility by the poor. Key informants believed farmed fish were more expensive than wild ‘local’ fish. Due to the regularity of their production volumes, tilapia farms controlled the market price of tilapia and stabilised it. Prior to the tilapia farms, local tilapia prices were highly elastic and based

on catch quantity; with the emergence of tilapia farms, fishers could sell tilapia at a higher price even when catch was high. Whereas elders reported stories of growing up on fish freely gifted by fishers, the emergence of fish farms solidified the commoditisation of fish. As one key informant described, “Fishing used to be for food... Now, people realise fish is money. Fish is a business and fish cannot be given for free.”

In addition to negative effects on accessibility of fish for the poor, the initial development of tilapia farming brought social and political unrest. The conflict between the community and tilapia farms was touched on by a variety of key informants. The community initially protested the new tilapia farms despite the farm having complied with legal requirements. Their dissent required the tilapia farms to negotiate terms of beach access and coexistence with the community to attain Social License to Operate (SLO). The tilapia farms now mainly ensure SLO through generating employment, creating communication and outreach platforms directly with community representatives, and sponsoring community development projects (e.g., scholarships, subsidising life jackets for fishers, etc). The persistence of traditional noncentralized governance in areas with aquaculture development regulated by modern centralised governance has also been described by Sanon et al. (2021).

Fishers and local residents of one particular impoverished littoral village commented that some tension still exists between tilapia farms and the fisheries industry. This was mainly due spatial conflict and residual perceptions that the tilapia cage farms cause pollution. Firstly, the tilapia farms concession spaces are de-facto non-fishing zones, reducing fishing space. Secondly, some people thought that the tilapia farm caused chemical pollution and reduced Nile perch catch (though not omena). Key informants with these negative views expressed anger because felt that their lake and beach had been sold by BMUs to the fish farms at their expense. While the BMU members and other government officials agreed that the concession spaces caused spatial conflict, they disagreed that the tilapia cage farm affected fisheries or the environment. One BMU representative said, “the cage farm put wastewater into lake, but I see fish surviving in waste water ponds.” Indeed, most people disagreed that the tilapia farm was polluting the water (Figure 27).

In summary, local cage culture was generally welcomed as sources of employment, were associated with several key social and financial benefits, and aspired aquaculture entrepreneurship. Furthermore, they were perceived to have potentially alleviate pressure on fisheries, mainly by supporting alternative employment for fishers. Additionally, several challenges associated with its emergence were identified, mainly concerning it SLO and financial accessibility of entry into the industry. In terms of food security specifically, the local fish farm had indirect impacts through increased employment and cash flow within the community. The indirect impact of aquaculture on local food security was also evidenced by other authors (Hishamunda & Ridler, 2006; Kaliba et al., 2007; Iruo et al., 2018; Gronau et al., 2020; Sanon et al., 2021). However, it had minimal direct impacts on local food security and, with the exception of fish donations, did not improve local

availability of fish. While a few key informants described that the tilapia farm improved the availability of fish, these key informants were recipients of fish donations. Only one key informant who did not receive fish donations mentioned that fish farms improved the availability of tilapia nationally but not locally. He explained that because the tilapia farms used their cold-chain equipment to sell mainly to distance markets or at their local shop rather than in the local market. Thus, residents did not feel that the farms improved the local availability of fish. Rather, the emergence of aquaculture and its market control over the price of fish may have decreased the affordability and accessibility of fish by the poor.

“The future is not in the lake.”

When asked about what could support food security in the area, respondents discussed adaptations and changes to terrestrial agriculture and livestock rearing. Youths envisioned a future where agricultural production is supported through technologies and infrastructure. In particular, they cited the need for better roads, irrigation, waste management, and better animal welfare (Figure 39). While public investments have become apparent in the last 30 years – for example, paved roads – key informants stated that these efforts were insufficient in addressing the increasing food insecurities. In addition, youths believed sensitisation was critical for improving waste management and reducing the risks of disease. They also devised that animal welfare issues in livestock husbandry could be addressed through sensitisation. Both youths and politicians stressed the need to diversify farming, create financial support schemes (like microfinance), increase smallholder and youths’ engagement in farming, and improve access to technologies like plowing equipment and irrigation. Youths also brought up the need for shaded areas for omena dryers, to protect them from the sun while they worked. Specific requests from other key informants included better equipment for farming, improved cattle breeds for milking, equipment and capacity for poultry farming, irrigation systems, and microfinancing opportunities. Generally, government officials, fish farmers, and youths believed that it was the government’s responsibility to make these changes and address food insecurities in the area.



Figure 39: The main road in Sindho is dirt, often flooded during the rainy season, inhibiting trucks and motorcycles from transporting goods.

Youths were convinced that farming was the future – but on what basis? Young peoples’ dream may be unfounded in the realities of intensified farming practices. In the absence of modern, intensified farming systems, they may have lacked a real understanding of modern agriculture and its costs and profit margins. Young people who saw a failure of the fishing industry and an abundance of unfarmed land, they reasonably looked towards farming as an opportunity. As no young people were actually observed participating or trying to participate in intensified farming, these dreams may be unfounded in reality. In this way, farming livelihoods may have been dreams rather than planned aspirations.

Despite the reliance of this community on fish, key informants did not envision fisheries or aquaculture as a mechanism for food security in their futures. Elder fishers and older BMU representatives described how youth were relying on the lake for their livelihoods in the absence of employment opportunities and being left without success. Jaded from the continual cycle of ‘boom and bust’ fisheries, agriculture was perceived as a more reliable source of income, (see also: Geheb & Binns, 1997). Youths and even fish farmers perceived that food security would be derived from the land rather than the lake because of the high investment costs required to invest in aquaculture paired with dwindling fish stocks and unreliable catch. Fears of a future without fish were also shared with Allegretti (2019). Rather, youths noted that livestock and crop farming had better predictability

than fishing, particularly when irrigated. Only fishers and fisheries governance noted a need for better fishing equipment, likely due to their personal investment in the fishing industry.

People were willing to change professions and embrace change that might improve their food security. For instance, youths described a desire to explore novel income-generating activities that engaged with the wider markets, like cutting papyrus or collecting water hyacinths for basket weaving and crafts that could be sold in urban centres. One woman also mentioned bee-keeping for honey production. One omena dryer said, “I will embrace anything that will bring change to my life – even change lifestyle from omena business.” Elders and adults noted the dire lack of employment opportunities for youths, stressed the importance of traditional education in enabling employment, and believed youths could be empowered through increased knowledge, money, and time; in contrast, the youths perceived that they were simply still searching for their business niche, demonstrating entrepreneurial spirit.

The tendency to envision a future outside the lake is likely a result of fisheries productivity decline, high competition for aquaculture employment, and an awareness of the high cost of imported foods. However, attitudes may differ between land-owners and non-landowners, where landowners have a greater potential for income generation from their land resources. Thus, more robust research on levels of landlessness and its effect on food security is warranted.

8.3 Discussion

Locals viewed aquaculture as a ‘modern’ version of fishing, rather than a distinct or competing industry. Overall, fish farming was welcomed into the community as complimentary to fishing. In contrast to the ‘traditional’ and deteriorating fishing industry, which was tarnished by its risky and dangerous reputation, fish farming employment that provided a dependable income was respected and coveted. Because of employment opportunities, local residents were positive about and in favour of industry growth. Furthermore, locals believed aquaculture would support the fishing industry through employment opportunities. Employment generated by aquaculture would continue to convert fishers into fish farm employees, reducing pressure on fisheries and improving catch-per-unit-effort for remaining fishers. Indeed, the emergent tilapia cage culture industry provided ample employment opportunities, with financial knock-on benefits to local economies. As wealthy boat-owners themselves, many BMU members had vested interest in increasing catch and reducing their competition on the lake (Barratt et al., 2015). Tilapia cage culture representatives believed their concession spaces may contribute to the conservation of fish stocks by acting as no catch areas, although robust evidencing is required.

Commercial-scale cage culture was encased in ambiguities. It offered several additional benefits to the community, including reduced crime, local economic stimulation, and support for small to medium-scale pond farm entrepreneurs. For instance, income from aquafarm employment supported

the local economy through increased local spending. As a result, employment in aquaculture would also decrease the prevalence and participation in crime and alcoholism associated with the fishing industry and absence of local employment opportunities. Emergent aquaculture did not affect migration patterns and was associated with some continued social tension arising from cosmopolitisation: migration into Sindo and its surrounding villages was originally driven by fishing, but now increasingly by employment opportunities in aquaculture. Several consequences of emergent aquaculture were also identified: cage culture increased and stabilised fish prices so that fishers could no longer increase fish prices during low productivity. Paradoxically, cage culture brought an initial period of social unrest until social license to operate was attained from the community at large. While terrestrial conflicts seem to be resolved, ongoing spatial conflict on the lake between fishers and cage farms was still a concern, which is being addressed at a national level (Aura et al., 2021; Mabula et al., 2023; Nyamweya et al., 2023; Longline Environment et al., 2024).

Overall, **the population was in favour of aquaculture expansion**. Mainly, they saw its potential to generate employment; however, the fish farms' employment opportunities will be at the same scale as fisheries opportunities and its ability to become an employment substitute for fisheries is likely limited. They also viewed aquaculture as a new and favourable use of farmland. Large-scale aquaculture driven by international investments inspired locals to start up their own fish farms. While they were aware that the investment requirements made cage culture unattainable for locals, some entrepreneurs aspired to pond farming, which has lower technological and investment pre-requisites. Not only providing inspiration, some commercial aquafarms supported these pond farmers through capacity building and seed provisioning. Indeed, these benefits birthed their social license to operate in this rural area. Should small-scale pond aquaculture develop, it may have positive implications for food security, as seen elsewhere where farmers' consumption of their own farmed fish supported their food security during lean periods (Kaminski et al., 2024). Conversely, the likelihood of pond farming impacting on farming households' food security may be unrealistic considering the trend towards selling food. Research is required to examine whether small-scale pond farming would be competitive with fishing and large-scale cage farming.

While aquaculture supported food security indirectly through employment, its direct effects on local fish provisioning was limited, as most locals sourced fish from the lake. While most people still sourced and preferred to source tilapia from fisheries, cultured fish were consumed with increasingly frequency as a result of emergent local aquaculture. **Yet, it was only affordable by better-off people, and worse-off people ate farmed fish significantly less frequently than better-off people** (as shown in Chapter 7). It is possible that the urban poor may benefit more from farmed tilapia than the rural poor (Kaminski et al., in prep). In Asia, tilapias are a food for the poor (Little, 2000; Belton et al., 2014; Belton et al., 2018), attributed to their low-technology reproduction and capacity for a variety of aquatic environments coupled with declining availability of small indigenous fish (Barman et al., 1999; Edwards, 2000; Little, 2000). In the present study, potential lower-income

tilapia consumers still have access to omena and lack access to small, affordable, farmed tilapia. As such, tilapia remains a luxury item. Although aquaculture has the potential to transition the area into a specialist and efficient fish producer, it seems to be currently developing into an “aqua-nationalism” system, where production is oriented towards the local market but there are reduced local choices and higher food prices (Gephart et al., 2021). Driving down prices via mass production, similar to an “aquatic chicken” system, may increase its affordability, but could have environmental consequences for the lake and focus on tilapia only would limit agro-biodiversity (Gephart et al., 2021). Overall, **aquaculture was not directly supporting the local food security of the poor**. If anything, the stabilising effect of aquaculture on fish prices limited the ability of the poor to access tilapia on days with high fish catch that would have otherwise driven down fish prices. Should overfishing continue, the local community may be increasingly forced to source fish from aquafarms as provisioning from fisheries declines. In this case, fish accessibility will be limited to those who can afford prices set by large-scale aquaculture corporations requiring profit margins for financial sustainability. This begs the question: what would that future scenario mean for the poor? At the time of this study, the poor were already unable to afford fish and instead relied on more affordable omena. On the contrary, increased employment opportunities in aquaculture may offer a way out of poverty. The indirect effects of fish farm employment on food security indicators were not measured in this research; however, research using stratified sampling approaches to compare food security indicators between fish farm and non-fish farm employees is recommended.

More research on independent Mama Samaki (women vendors selling fried or smoked Nile perch and tilapia) is required, as little literature exists on their livelihoods or position. Mama Samaki's seem to reap higher livelihood rewards, although this requires more detailed research. This role may provide opportunities for women to engage in the value-chain without relying on low-value omena. Mama Samaki may be supported by the consistency and quality of farmed fish supply (Kaminski et al., in prep). Fish farms may require Mama Samaki for consistent sales outlet, and it may be in their interest to support these female vendors.

As aquaculture has developed globally, small pelagic fish have been used as aquafeed ingredients to the detriment of local food security (Naylor et al., 2000). Additionally, local Kenyan researchers have encouraged its export (Aura et al., 2022). **The potential export and/or use of omena for aquafeed as Lake Victoria's cage culture develops both pose significant threats to the food security of the poor**. Thus, aquaculture development has trade-offs. On the one hand, its potential use of natural resources may have unintended negative consequences for the poor, such as redirecting omena supplies away from direct human consumption locally. A robust value-chain analysis would illuminate to what extent omena is currently prioritised for feed mills versus human consumption. On the other hand, animal and aquafeed producers are drastically reducing the amount of fishmeal inclusion and the competition for omena with human consumers may be increasingly lessened over time with ongoing advancements. Opportunities for omena quality differentiation within the value-

chain could support both: high-quality omena could be prioritised for better processing to produce higher-quality human food, and poorer quality omena could be directed to feedmills. Additionally, employment-generation in rural areas can support livelihoods and purchasing power for diverse diet, which is particularly relevant in this study area because food security was strongly linked to wealth. Development to alleviate poverty in the study area should aim at improving income-generating opportunities, which the burgeoning aquaculture industry would likely provide. **Fish farms should produce smaller tilapia, which may be more affordable to poorer consumers and fulfil the demands for aspirational diets that include fish** (Kaminski et al., 2024; Kaminski et al., in prep). Analysis is recommended to understand nutritional equivalencies – i.e., how much omena is required to produce a portion of tilapia, and how that portion's nutritional composition compares to that of the omena required to produce it.

Meanwhile, local agriculture development should not be neglected, as locally produced foods could improve the affordability of a diverse diet, supporting food security of the poor. Potential synergies of agri-aquaculture systems could benefit the food system: for example, Victory Farms was partnering with local farmers, digging ponds on their plots for tilapia seed production and crop irrigation with nutrient-rich water used for fish culture (Moran, 2023, personal comms). Development of local feed mills for aqua-feed might stimulate non-maize crop production, with potential consequences for food security and agro-biodiversity. Many respondents believed that food security in the study area could be supported through agricultural intensification. Youths assessed the resources available to them: inheritable family land; decreasing forageable products; increasingly risky, dangerous, and disrespected fishing and omena value-chain; and extreme competition for aquaculture employment. They concluded that their future food security thus depended on terrestrial agriculture and not the lake resources. Many from farming families themselves, they require improved agriculture capacity and technology to increase the quantity and diversity of locally produced foods. Farming livelihoods may be dreams unfounded due to lack of local experiences about the realities of intensive farming methods. The qualitative work questioned whether youths' vision - that future food security would be based on terrestrial agriculture - might be variable based on land ownership. Indeed, those who rented land did not believe renting land for crop production was profitable. New models are required, as poorer people producing food on rented land can be highly productive: pond rentals for fish production in West Bengal have been successful (Arthur et al., 2005). The quantitative work found that 63% of my randomly selected respondents for the questionnaire owned land, 24% rented land, and 17% both owned and rented land. The area may already be trending away from fisheries and towards land-based livelihoods: participants perceived fishing income to be significantly more pervasive (70-90%) that was estimated by the randomly sampled household survey (32%; Chapter 6).

In summary, the development of aquaculture is wrought with tensions, paradoxes, and ambiguities (Figure 40). Currently, direct nutrition gains from tilapia cage farming are limited (see also Kaminski

et al., in prep); yet, cage farming offers much needed employment opportunities with knock-on economic benefit to communities. Thus, aquaculture offers benefits as well as detrimental consequences, changeable with the characteristics of the businesses and adaptations of the community. The holistic approach has allowed us to understand these tensions, complexities, and nuances that might be missed in siloed approaches. Answering the question “Is aquaculture pro-poor?” in Kenya’s Lake Victoria requires understanding and embracing the complexity of the whole food system and pathways to impact (Edwards, 2000; Little et al., 2012; Toufique et al., 2014; Olaganathan & Kar Mun, 2017).

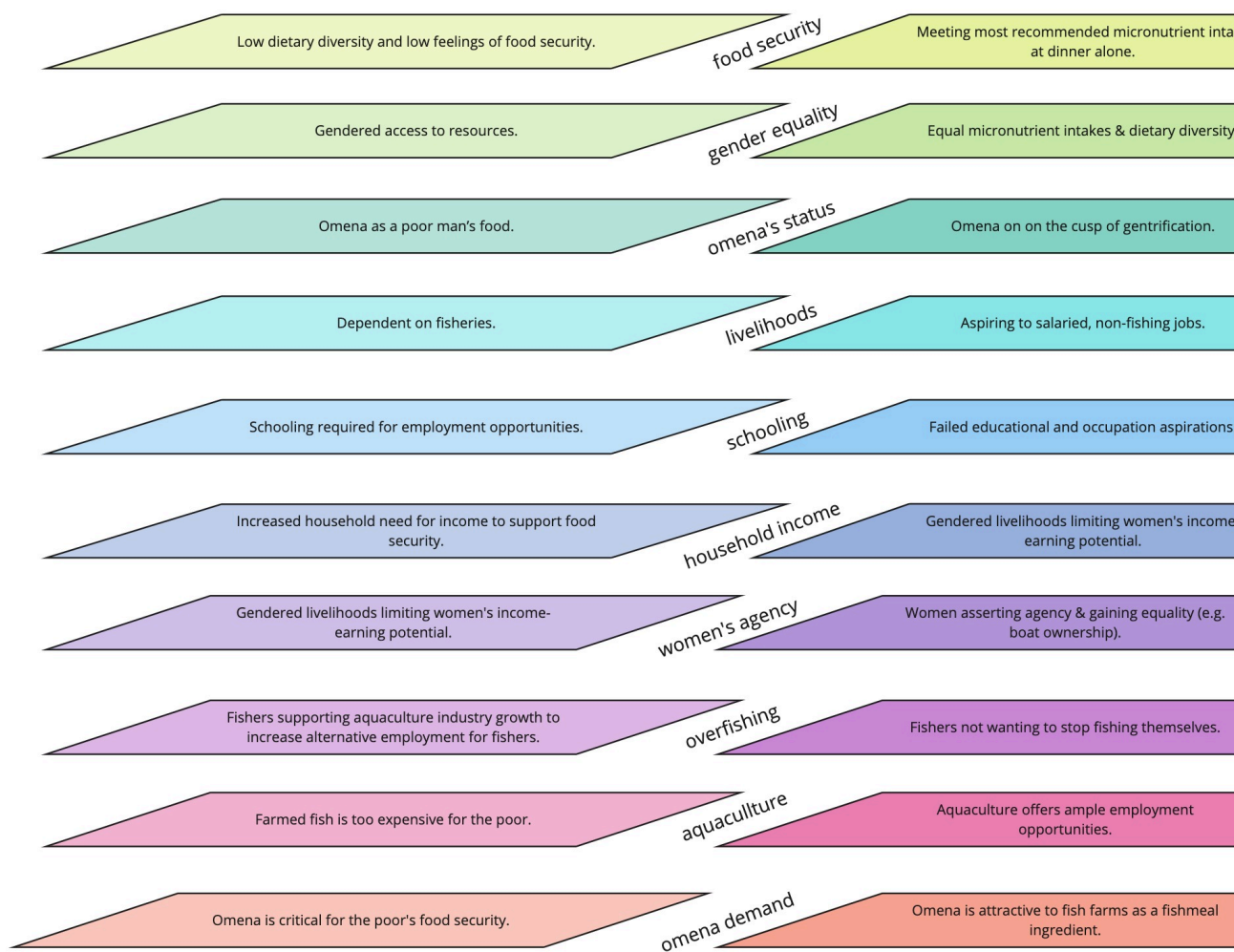


Figure 40: Conceptual diagram of ambiguities and ambivalences discussed throughout this thesis..

Chapter 9: The future of food security: development & policy recommendations

As recommended by Geheb and Binns (1997), this thesis has conducted in-depth exploratory research to identify development opportunities on the Kenyan shores of Lake Victoria. Based on my findings, several opportunities for improved food security can be proposed. Development and policy for food security should aim to increase dietary diversity and improve food experiences through improved income-generation opportunities. First, dietary resilience can be improved through supporting dietary diversity. Increasing access to fish compared to other ASF is important due to its relative affordability, its denser nutritional composition, and cultural value. Broiler chicken production has not developed locally due to disease, predation, feed scarcity, and anti-microbial resistance (Olwande, 2008; Otieno, 2023). Supporting chicken production would likely economically benefit chicken farmers only (as chicken production is not labour intensive) and increase chicken accessibility by the upper and upper-middle classes; increasing the availability of fish would benefit a wider range of socio-economic classes. Raising awareness of the nutritional importance of eating a variety of fruits and vegetables might also translate into more diverse diets.

Second, this study area's population must be able to earn better income to afford animal source foods and a larger variety of fruits and vegetables to improve their dietary diversity and food resilience. While my analysis suggests that diets are likely to be nutritionally sufficient, participants expressed a desire for more diverse diets. Furthermore, diversification is a key component of resilience (Béné, 2020). Dietary patterns suggest that more diverse diets are reliant on food imported into the area – since these foods are more expensive than local foods, imported foods are accessible by the wealthy only. Thus, a diverse diet must be purchased (unless local agricultural production intensifies and diversifies). Because current tilapia consumption is low, greater consumption of locally farmed, nutrient-dense, small tilapia would constitute dietary diversification – but the tilapia must be affordable. Higher diversity of income-generating activities was associated with more diverse diets elsewhere in Kenya (Kamau-Mbuthia et al., 2023) and is recommended to support fisher livelihoods globally (Allison & Ellis, 2001). Food commoditisation can support food security if cash crop income can support food purchasing (Longhurt, 1988).

As a part of improving income-generation, interventions that increase omena dryers' opportunities for higher-value positions are needed, supporting these worse-off women to increase income from omena drying and direct more resources towards their household food security. Co-operatives could support them to upgrade their livelihood opportunities and power in the value-chain. Strong support from governance would be required to help balance power across the value-chain. Raising awareness and rallying political protection of these currently invisible women is essential. Lessons can be learned from the seaweed industry which is similarly gendered, affecting roles, wages, and decision-making power (Mengo et al., 2023). For instance, policy can prevent asset accumulation by the

better-off, improve product quality through access to credit and drying technology, and increased empowerment through cooperative groups and representation in governance structures.

Third, fish have a strong cultural and economic value as food: through an improved ability to choose foods, the local ‘fish eating’ historical ethnic identity can be preserved by enabling more people to access fish (and other foods) they want to eat. Supplementary to development activities aimed at improving income-generation, research to identify and advertise the most affordable food sources of potentially deficient micronutrients (as identified by this thesis: zinc, calcium, and for women, iron) could have more immediate benefits (Ryckman et al., 2021). Diversification of fish products – particularly fish snack foods using processed omena – could also increase nutrient intake from fish (Sigh et al., 2018). The resiliency of the omena fishery is understudied, but clearly one that is heavily fished and underpins nutritional security, particularly for the poor; thus its management enabling its accessibility is critical and should be a priority for the LVFO and the three governing countries. Tilapia farms could increase their production of small tilapia using partial harvests production strategies for more inclusive business models that increase the availability of small affordable tilapia for poorer consumers (Kaminski et al., 2024).

Fourth, education around the nutritional value of cheap, locally available foods (like omena, indigenous leafy green vegetables, and fruits) may help people feel more food secure and have better satisfaction and experiential (subjective) food security. While monotonous and linked to lower social status, these foods are indeed providing adequate nutrition across several nutrients. This may alleviate discontent in spite of their low status or even alter their low status itself. Education should also encourage women and girls to consume larger quantities of locally available iron-rich foods compared to men in light of their higher iron requirements.

Fifth, local consumption of omena has clearly been a long-term reliance which, until now, has been understudied and overshadowed by the lucrative Nile perch industry. With the Nile perch industry decline, research on the omena fishery and its value-chain are critical to inform omena fisheries policies that safeguard this natural resource that is so critical for local food security.

Chapter 10: Conclusions & policy recommendations

This thesis aimed to examine the state of littoral communities' food security, their livelihoods, and the role of fish within on the Kenyan shores of Lake Victoria, and found the following answers to our research questions:

How do different demographics feel about fish in their diets, food culture and food security? What role do fish play in traditional recipes and have those recipes persisted? Do fish still have cultural value as food? Food insecurity feelings were high, and people felt that their food security has worsened over time. They directly related this to decreased cash flow within the community from declining fisheries productivity, although it is more likely a result of increased populations densities rather than failing fisheries. Fish continue to have a strong cultural importance in food culture as a staple food. Fish recipes have changed: slowly-cooked soups with an array of different fish species have been replaced with a few fried species due to the Lake's decreased biodiversity, the increased accessibility of oil as sourcing fuel has become more difficult (due to deforestation and rising fuel prices) and an increased need for women to engage in income-generating activities thus reducing the time available for cooking.

Through what pathways are people from different socio-economic groups accessing fish, and what are their barriers to fish consumption? Financial and environmental capital were important for acquiring fish, and fish consumers mainly purchased fish. Affordability and cash for purchasing were the main barriers to dietary diversity and fish consumption; omena was the exception, as it was widely available and its portionability enabled its purchasing in proportion to each customer's cash allowance. Omena was disproportionately important for the poor. Although the poor felt unable to afford other fish, people across all demographics were eating Nile perch and tilapia regularly, suggesting that hidden, illegal economies may exist that were not clearly illuminated by this research. While engagement in the Nile perch and tilapia value-chains did not directly contribute to household fish consumption, engagement in the omena drying business directly contributed to household omena consumption because the women dryers often retained a portion for household consumption.

How does the micronutrient contribution of fish compare to other commonly consumed foods? To what extent are fish a source of micronutrients, and does that vary between socio-economic class or generation? What other barriers to nutrition security do they face? This work found that diets were nutritionally adequate but highly reliant on maize, omena, and indigenous leafy green vegetables. Omena had disproportionate nutritional importance in worse-off diets. The lack of dietary diversity is a risk to the food system's resilience. Diets have increasingly relied on purchasing food, and thus food security has worsened over time due to declining income from the Nile perch industry and lack of employment opportunities. The main barrier to food security in the area is a lack of income-generating opportunities that would enable food purchasing. Besides fish and the three staple foods above, other food was not or was underproduced locally and thus less affordable.

What micronutrients are being supplied through commonly consumed fish? What role do fish from fisheries and aquaculture play in the provisioning micronutrients? Are cultured fish a substitution for, or supplement to wild caught fish, and how does that impact on micronutrient intake? Second only to maize, fish were the main contributors of nutrients and consisted of three main species: omena, tilapia, and Nile perch. Only wealthier locals benefited from farmed tilapia consumption. Most local people were unable to afford farmed tilapia in their diets. Omena consumption was ubiquitous across demographics. Omena was more micronutrient-rich than tilapias and Nile perch. Among the larger fish species, Nile perch were the least nutrient-dense fish and smaller tilapia were more micronutrient dense than larger tilapia. Considering that the population may have lacked sufficient zinc and calcium intakes, small, farmed tilapia may be a better choice for consumers than wild tilapia because of its higher zinc, calcium, and Vitamin B12 concentrations (although not nearly as much as omena). Omena was critical for local food security as a direct and affordable animal source food that provided an array of nutrients. People, particularly the poor, aspire to eat more large fish and less omena, which has shaming association with poverty. Omena may be on the cusp of gentrification as some wealthier people are beginning to realise its nutritive value, but require higher-quality product.

What role do fish from fisheries and aquaculture play in the provisioning of livelihoods? Nile perch and its export-oriented value-chain was previously a source of income, but people were now aspiring to other jobs due to its industry's demise. While key informants estimated that most households were engaged in the fish value-chain, our household survey found that only about a third of households were engaged in the fish value-chain. Despite that the direct reliance of households on fisheries for employment was declining, little outwards migration existed, and people looked for other jobs locally. Amongst a context with few employment opportunities, tilapia farming made indirect contributions to food security through employment generation. Because of its employment, aquaculture was viewed positively overall and had positive economic knock-on effects in the community; however, aquaculture has a capped ability to supply employment and alternative income-generating activities are necessary.

Based on these findings, several interventions could support improved food security. Dietary diversification would enable better experience of food security and increase food system resilience. Diversification requires improved purchasing power and expanded local agro-biodiversity. Increased access to fish specifically would improve dietary diversity and dietary satisfaction in alignment with local food culture and ethnic identities as 'fish eaters'. Development of alternative and diversified income-generating activities may also support livelihoods and thus food security. In the meantime, sharing the results of this work – that their main meals are nutritionally sufficient and that omena is a nutritional powerhouse – may provide more immediate improvements to food insecurity experiences. Gendered approaches to value-chain development might lead to improved translation of economic activity into household food security. Improving women's agency, their engagement in

income-generation, and their access to credit would likely result in food security improvements. Formalised cooperatives and representation in governance may improve omena dryers' ability to improve the quality and thus value of their product. These cooperatives should be enabled to develop additional value-added products like fish wafer snacks, that would improve their products' value and also increase fish intake locally. Meanwhile, fish farms should continue indirect impacts on local food security by providing ample employment opportunities and begin supplying smaller fish that are more affordable to create direct impacts on local food security.

Several areas of additional research in the area are needed. Qualitative methods of engaging with local stakeholders is critical to identify, avoid, and/or minimise adverse effects on local experiences throughout any development interventions or policy changes. More in-depth dietary diaries for 24-hour diet data would validate this thesis' findings. Particular attention to elderly people's diets and potential hidden food economies are also recommended. Additional research on diets using stratified sampling approaches is warranted to compare the effects of orphans, monogamous versus polygamous households, and fish farming versus non fish farming households on household food security. Differences in food security between fish farm and non-fish farm employees should be examined using a value-chain approach to understand if aquaculture employment improved food security. A complete and robust value-chain analysis for omena is also needed.

The effect of aquaculture commands more attention. The potential links between the emergence of aquaculture and its effect on local agriculture requires research to anticipate synergies and conflicts:

(a) between local aquafeed production and food security (i.e., omena use, tilapia affordability, and crop production), Modeling is recommended to understand the optimum use of omena, either for direct human consumption or value-addition into tilapia for aspirational diets. Modelling results would inform policy decisions around regulatory controls on the harvest and use of omena.

(b) of agri-aquaculture systems, where pond farming might support crop production by enabling irrigation. Cooperative arrangements between pond farms and crop farmers for irrigation and water-sharing in polyculture systems shows promise in other areas of Sub-Saharan Africa (see: Kaminski et al., 2022).

Ongoing interdisciplinary research, like within this thesis, is needed around the lake to better understand and monitor local food security over time. This includes qualitative methods that engage local stakeholders to identify, avoid, and/or minimise adverse effects on local experiences throughout any development interventions or policy changes.

In conclusion, this thesis has made novel contributions to the literature. It has used existing methodological tools and indicators in novel ways and combinations for a multidirectional

understanding of the role of fish in food system. Without this mixed methods approach, nuances, ambiguities, and ambivalences may have been missed that were important for a holistic understanding of the role of fish in local food security. Multiple indicators are essential to making conclusions about the state of a community's food security. Paradoxes, complexities, and nuances can be missed using mono-disciplinary approaches. Additionally, this thesis has provided an updated state of affairs on the food security of littoral communities on Kenya's Lake Victoria, which can be used to compare elsewhere around Lake Victoria and in other Eastern Africa's freshwater lakes.

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Appendix

Appendix 1: Example of guiding questions used during the semi-structured key informant interviews and focus group discussions. This particular example was for focus groups with women. Additional probing questions (e.g., “Could you tell me more about X?” or “How did you feel about Y?”) were used to more deeply explore additional topics that arose during the conversations.

Key Informant Interviews – FEMALE COMMUNITY

I'd like to ask you a few questions about your village.

- Can you please list the types of livestock that are kept in your village? Can you please list the types of vegetables that are grown in your village?
- Are there specific areas where livestock graze? Where vegetables are grown?
- Do you need to buy any food types brought in from other areas? Or do you only eat food that is produced in this village?
 - How do people obtain water and firewood? Other items (clothing, oil...)
 - How many people do you cook for every night? Who does the cooking? How do you choose what foods to make for your household?
 - Can you describe some of your favourite meals that your household eats? How is it cooked? Do other people also eat these meals?
 - What traditional customs exist around food preparation? Are there special meals or foods you eat during certain special events or at certain times of the year?
 - Do you have any problems with getting enough food, or the types of food you prefer? Can you describe these problems?
 - Thinking back to when you were a child: what types of food did you eat as a child, and is that different from the types of food you eat now? How so?
 - What resources do you forage or use from the environment? Are these more or less available now than 10 years ago? Are you able to access the resources you need?
 - Which resources are not available enough (scarce)? Which resources are very available (abundant)?
 - Do any resources create problems for your village?
 - Could you describe the different groups of people in your village? What makes someone well-off? What makes someone poor? What age are the ‘youth’? What age are the ‘elders’? Who is the most respected group of people and why (status)? Do the poorest households live in certain areas (such as on the edge of an area/village) or is everyone mixed? What are the different religions in your village?
 - How do people make money in your village? What are the main differences in activities of men versus women versus children versus elders? How has that changed since you were a child?
 - Do any certain groups of people eat differently than others? Rich versus poor, men versus women, elders versus youth...
 - Do certain areas or people in your village have particular problems? Particular opportunities?
 - Do you participate in fishing activities? *[if yes]* Can you describe the process for me? (how the fish is purchased? processed/dried? Sold?) What is the benefit of these activities for you and your family? What are the biggest problems you have related to these fishing activities?
 - Has your village experienced any shocks in the last 10 years? How did your village change to cope or adapt to these shocks?

- I've heard that the fisheries in Lake Victoria have declined in the past 10 years. Do you agree with this? If so, how has this affected your village compared to when there were more fish in the lake?
- Has the appearance of cage farms changed anything in your village or your life?
- How do you feel about the cage farms? What advantages or disadvantages do you think the cage farms have for your household and village?

Appendix 2: A triplet of ice-breaker activities offered to the youths before beginning the core research activities. Each ice-breaker activity was described briefly, and youths collectively discussed then agreed to do “Two truths and a lie”. When describing each ice-breaker, I provided an example using myself for them to try the game before committing. The aim of all three games is to increase familiarity between participants, inspire a relaxed atmosphere, and use silliness to reduce power inequalities between the participants and the researchers.

1. “Either or?” is a game where one person selects two items or actions, and asks the group to decide which item or action they would prefer. The game can unfold in various ways. Participants can simply explore their peer’s preferences (e.g., “Would you pick an apple or an orange?” or “Would you rather play football or rugby?”). More vulnerable and meaningful conversations can develop when the person chooses difficult items or actions to choose between (e.g., “Would you rather see the future or change the past?”). Joker archetypes can also enjoy this game and invoke silliness (e.g., “Would you rather have a pig’s tail or bunny ears?”).
2. In “Two Truths and a Lie”, each person thinks of two truths and a lie about themselves and presents all three to the group. The group then converses among themselves and guesses which of the three is the lie. That person’s turn is over when the group discovers the lie. For instance, my list included “My favourite food is avocado”, “I love running”, and “I know how to change the oil in a car”. The group guessed correctly that I actually hate running.
3. One person starts by saying, “Never have I ever...” and then says something they have never done. If anyone in the group has done that action, they hold up their hand. In my example, I offered “Never have I ever caught a Nile perch”. Four participants raised their hand because they had indeed previously caught a Nile perch.

Appendix 3: Inter-household survey tool uploaded to KoboToolBox mobile application.

Interviewer Name: _____ Date: _____ Village/Location: _____

1. Family Member Self; Spouse; Grandparent; Child; Orphan; Other relative; Friend; Other	Age	Gender M/F	Main occupation (Specify if at a tilapia farm)	Highest Education? None; Primary; Secondary; College; University; Post-graduate

2	Is your household part of any social groups? [multiple]	Δ I am not part of any Δ Church or religious group	Δ BMU. Δ Youth group	Δ Merry-go-round / table band Δ Women's group	Δ C
3	Do you or anyone in your household forage or collect any resources (eg food, fuel) from the environment/from the wild?	Δ I do not forage. Δ Firewood for cooking Δ Firewood for selling	Δ Termites/Insects for eating Δ Indigenous greens for eating Δ Indig. Greens for selling	Δ Other:	
4	What size is your owned land (in acres)? [if no land owned, then 0]	#			
5	What size is your rented land (in acres)? [if no land rented, then 0]	#			
6	How far away is your land (rented or owned)?	In km:			
7	Do you grow crops on your land (rented or owned)?	Δ Yes Δ No [Go>11]			
8	What portion of your crops do you sell versus eat yourself?	To sell: _____ %			
9	What crops do you grow? [list]	Purpose?	What crops do you grow? [list]		
	a.	Δ To Eat ΔTo Sell Δ Both	h.		
	b.	Δ To Eat ΔTo Sell Δ Both	i.		
	c.	Δ To Eat ΔTo Sell Δ Both	j.		
	d.	Δ To Eat ΔTo Sell Δ Both	k.		
	e.	Δ To Eat ΔTo Sell Δ Both	l.		
	f.	Δ To Eat ΔTo Sell Δ Both	m.		
	g.	Δ To Eat ΔTo Sell Δ Both	n.		
10	What challenges do you have with growing crops? [multiple]	Δ Can't access fertiliser Δ Can't access equipment Δ Can't access seeds	Δ Can't afford fertiliser Δ Can't afford equipment Δ Can't afford seeds	Δ No irrigation Δ Poor rainfall patterns Δ Crop damages from livestock/people	Δ
11	Do you or anyone in your household have monetary savings?	Δ Yes			
12	If you no longer had any income, how long could you live off your savings? (months)				

13. Income Activities (What ways does your household make money?)	14. Number of pebbles	15. Expenditures (What ways does your household spend money?)	16. Number of pebbles
a.	#	a. Omena/fulu	#
b.	#	b. Fish	#
c.	#	c.	#
d.	#	d.	#
e.	#	e.	#
f.	#	f.	#
g.	#	g.	#

14	Where do you get your drinking water?	Δ I buy bottled water or I get water piped to my house. Δ I collect rainwater	Δ I buy Δ I carry it from the lake Δ Other
15	Do you treat your drinking water?	Δ Yes, with chemical tablets	Δ Yes, I boil it Δ Yes, I boil it
16	What is the primary fuel you use for cooking?	Δ Purchased charcoal Δ Purchased firewood	Δ Homemade charcoal Δ Collected firewood
17	Do you own a motorcycle?	Δ motorcycle	Δ refrigerator Δ TV Δ bicycle
18	Do you own your house or rent?	Δ Own	Δ Rent
19	How many boats do you own? (#)	#	
20	How many of these animals do you have? (#)	Chickens/Ducks:	Goats: Sheep:
21	What type of lighting do you have in your house?	Δ Main-grid electricity	Δ Candles, paraffine, or wood
22	What material are your walls made of?	Δ Wood Δ Mud	Δ Cement & mud Δ
23	What material is your floor made of?	Δ Wood Δ Mud	Δ Cement Δ
24	Where do you go to the toilet?	Δ Private flush Δ Shared flush	Δ Field / in nature Δ
25	Do the women in your household get hair weaves regularly?	Δ Yes	Δ No
26	Do your children go to local school or boarding school?	Δ Local school	Δ Boarding school

27. Food List	a. Time	b. Occasion	c. Food/Drink	d. Description of Food/Drink and ingredient	e. How much of this food you actually consume?

28	Was the amount of food that you ate yesterday usual?	Δ Usual (<i>Go > 30</i>)	Δ Less than usual (<i>Go ></i>
a	What is the main reason the amount you ate yesterday was less than usual?	Δ Sickness Δ Traveling Δ On vacation/day off	Δ Short of money Δ Too busy Δ Not hungry
b	What is the main reason the amount you ate yesterday was more than usual?	Δ At a special event Δ On vacation/day off	Δ Very hungry Δ Bored or stressed
29	How many meals do you normally eat per day?	Δ 4+ Δ 3 Δ 2 Δ 1 Δ It changes	
30	How could you describe your current dietary habit?	Δ No special diet, I eat almost everything Δ Vegetarian	
31a	a. Do you ever eat omena/fulu?	Δ Yes Δ No	b. Did you eat omena/fulu as a child?
c	Do you eat as much omena/fulu as you like?	Δ Yes Δ I eat more omena than I would like. Δ I want to eat more but it's too expensive.	Δ I want to eat less Δ I want to eat more
32	What types of fish do you eat? <i>[multiple]</i> <i>[If none, skip to 33]</i>	Δ I don't eat fish Δ Wild lake tilapia Δ Nile Perch Δ Nile Perch Δ Pond tilapia. Δ Other	
a	Which part of the fish do you normally eat? <i>[multiple]</i>	Δ flesh Δ bones Δ eyes Δ skin Δ Other	
b	Which part of the fish do you prefer to eat? <i>[multiple]</i>	Δ flesh Δ bones Δ eyes Δ skin Δ Other	
c	What fish did you eat as a child? <i>[multiple]</i> <i>[if none, skip to e]</i>	Δ I didn't eat fish Δ Wild lake tilapia Δ Nile Perch Δ Nile Perch Δ Pond tilapia. Δ Other	

d	Which parts of the fish did you normally eat as a child? [multiple]	Δ flesh Δ bones Δ eyes Δ skin Δ organs Δ		
e	Which fish is easiest to find?	Δ I don't eat fish Δ Wild lake tilapia Δ Farmed tilapia Δ Nile Perch Δ Pond tilapia. Δ Catfish		
f	Which fish is most affordable?	Δ I don't eat fish Δ Wild lake tilapia Δ Farmed tilapia Δ Nile Perch Δ Pond tilapia. Δ Catfish		
g	How old were you when you started eating farmed tilapia?	Δ Age: Δ I never eat farmed tilapia, only w		
h	How many days per week do you eat...? (days/week)	Farmed tilapia		Wild lake tilapia
		Pond tilapia		Nile perch
i	Do you eat as much fish as you would like?	Δ Yes, I eat as much as I like. Δ I eat more Δ I want more but it's too expensive. Δ I more but Δ I want more but it's not always available.		
33	Does your child/children get fed at school / get school meals?	Δ 3 meals per day Δ 2 meals per day Δ 1 m		
Now I would like to ask you some questions about your food consumption in the last 12 months. During the last 12 MONTHS, was there a time when:				Yes
34	You were worried you would run out of food because of a lack of money or other resources?			
35	You were unable to eat healthy and nutritious food because of a lack of money or other resources?			
36	You ate only a few kinds of foods because of a lack of money or other resources?			
37	You had to skip a meal because there was not enough money or other resources to get food?			
38	You ate less than you thought you should because of a lack of money or other resources?			
39	Your household ran out of food because of a lack of money or other resources?			
40	You were hungry but did not eat because there was not enough money or other resources for food?			
41	You went without eating for a whole day because of a lack of money or other resources?			
42	If you had extra money, what would you spend it on first?			
43	If you had extra money and you had to spend it on food, what food would you buy first?			
44	Where do you normally buy tilapia from? Why?			
45	Where do you prefer to buy tilapia from? Why?			
46	How do you feel about the following statements?	Strongly Agree	Agree	Neu
a	"Fish catch is declining."			
b	"More and more people are fishing from the lake."			
c	"Fish are not used as gifts like they were when I was a child."			
d	"Crime has reduced since the cage fish farming business started."			
e	"Cage fish farming pollutes the water."			
f	"Cage fish farming provides employment opportunities for my community."			
g	"Migration into the community has increased in my lifetime."			
h	"Migration into the community has increased in my lifetime because of cage fish farming."			
i	"Fish is important for my health and a balanced diet."			
48	Do you receive any donations from a tilapia farm?	Δ Yes Δ No		

Appendix 4:

Date:

Intrahousehold 24-hour recall

Enumerator:

Village:

1. Interviewing the Mother

Mother's Age:

WEIA Questions:

1. Household ID Code: _____ [text box for number]

2. Ability to be interviewed alone: [Select one]

- Alone
- With adult females present
- With adult males present
- With adults mixed sex present
- With children present
- With adults mixed sex and children present

3. Type of household: [Select one]

- Male & female household
- Female household only

[SECTION A: QUESTIONS 4 THROUGH 12 REPEAT, BUT IN REFERENCE TO A DIFFERENT ACTIVITY EACH TIME, SEE IN BOLD TEXT]

“Now I’d like to ask you some questions about your participation in certain types of work activities and on making decisions on various aspects of household life”

4. In the past twelve months, did you yourself participate in Food crop farming? These are crops that are grown primarily for household food consumption. [Select one]

- No [skip to question 5]
- Yes

4a. When decisions are made regarding Food crop farming, who is it that normally takes the decision? [select multiple]

- Self [Skip to 4c]
- Spouse

- Other household member
- Other non-household member
- Not applicable

4b. How much input did you have in making decisions about Food crop farming? [Select one]

- No input or input in few decisions
- Input into some decisions
- Input into most or all decisions
- No decision made

4c. To what extent do you feel you can make your own personal decisions regarding Food crop farming if you want to? [Select one]

- Not at all
- Small extent
- Medium extent
- To a high extent

4d. How much input did you have in decisions on the use of income generated from Food crop farming? [Select one]

- No input or input in few decisions
- Input into some decisions
- Input into most or all decisions
- No decision made

5. In the past twelve months, did you yourself participate in Cash crop farming? These are crops that are grown primarily for sale in the market? [Select one]

- No [skip to question 6]
- Yes

5a. When decisions are made regarding Cash crop farming, who is it that normally takes the decision? [select multiple]

- Self [Skip to 5c]
- Spouse
- Other household member
- Other non-household member
- Not applicable

5b. How much input did you have in making decisions about Cash crop farming? [Select one]

- No input or input in few decisions
- Input into some decisions
- Input into most or all decisions
- No decision made

5c. To what extent do you feel you can make your own personal decisions regarding Cash crop farming if you want to? [Select one]

- Not at all
- Small extent
- Medium extent
- To a high extent

5d. How much input did you have in decisions on the use of income generated from Cash crop farming? [Select one]

- No input or input in few decisions
- Input into some decisions
- Input into most or all decisions
- No decision made

6. In the past twelve months, did you yourself participate in Livestock raising? [Select one]

- No [skip to question 7]
- Yes

6a. When decisions are made regarding Livestock raising, who is it that normally takes the decision? [select multiple]

- Self [Skip to 6c]
- Spouse
- Other household member
- Other non-household member
- Not applicable

6b. How much input did you have in making decisions about Livestock raising? [Select one]

- No input or input in few decisions
- Input into some decisions
- Input into most or all decisions
- No decision made

6c. To what extent do you feel you can make your own personal decisions regarding Livestock raising if you want to? [Select one]

- Not at all
- Small extent
- Medium extent
- To a high extent

6d. How much input did you have in decisions on the use of income generated from Livestock raising? [Select one]

- No input or input in few decisions
- Input into some decisions
- Input into most or all decisions

- No decision made

7. In the past twelve months, did you yourself participate in Non-farm economic activities? This would include things like running a small business, self-employment, buy-and-sell. [Select one]

- No [skip to question 8]
- Yes

7a. When decisions are made regarding Non-farm economic activities, who is it that normally takes the decision? [select multiple]

- Self [Skip to 7c]
- Spouse
- Other household member
- Other non-household member
- Not applicable

7b. How much input did you have in making decisions about Non-farm economic activities? [Select one]

- No input or input in few decisions
- Input into some decisions
- Input into most or all decisions
- No decision made

7c. To what extent do you feel you can make your own personal decisions regarding Non-farm economic activities if you want to? [Select one]

- Not at all
- Small extent
- Medium extent
- To a high extent

7d. How much input did you have in decisions on the use of income generated from Non-farm economic activities? [Select one]

- No input or input in few decisions
- Input into some decisions
- Input into most or all decisions
- No decision made

8. In the past twelve months, did you yourself participate in Wage and salary employment? This could be work that is paid for in cash or in-kind, including both agriculture and other wage work [Select one]

- No [skip to question 9]
- Yes

8a. When decisions are made regarding Wage and salary employment, who is it that normally takes the decision? [select multiple]

- Self [Skip to 8c]

- Spouse
- Other household member
- Other non-household member
- Not applicable

8b. How much input did you have in making decisions about Wage and salary employment? [Select one]

- No input or input in few decisions
- Input into some decisions
- Input into most or all decisions
- No decision made

8c. To what extent do you feel you can make your own personal decisions regarding Wage and salary employment if you want to? [Select one]

- Not at all
- Small extent
- Medium extent
- To a high extent

8d. How much input did you have in decisions on the use of income generated from Wage and salary employment? [Select one]

- No input or input in few decisions
- Input into some decisions
- Input into most or all decisions
- No decision made

9. In the past twelve months, did you yourself participate in Fishing? [Select one]

- No [skip to question 10]
- Yes

9a. When decisions are made regarding Fishing, who is it that normally takes the decision? [select multiple]

- Self [Skip to 9c]
- Spouse
- Other household member
- Other non-household member
- Not applicable

9b. How much input did you have in making decisions about Fishing? [Select one]

- No input or input in few decisions
- Input into some decisions
- Input into most or all decisions

- No decision made

9c. To what extent do you feel you can make your own personal decisions regarding Fishing if you want to? [Select one]

- Not at all
- Small extent
- Medium extent
- To a high extent

9d. How much input did you have in decisions on the use of income generated from Fishing? [Select one]

- No input or input in few decisions
- Input into some decisions
- Input into most or all decisions
- No decision made

10. In the past twelve months, did you yourself participate in Fish drying and trade? [Select one]

- No [skip to question 11]
- Yes

10a. When decisions are made regarding Fish drying and trade, who is it that normally takes the decision? [select multiple]

- Self [Skip to 10c]
- Spouse
- Other household member
- Other non-household member
- Not applicable

10b. How much input did you have in making decisions about Fish drying and trade? [Select one]

- No input or input in few decisions
- Input into some decisions
- Input into most or all decisions
- No decision made

10c. To what extent do you feel you can make your own personal decisions regarding Fish drying and trade if you want to? [Select one]

- Not at all
- Small extent
- Medium extent
- To a high extent

10d. How much input did you have in decisions on the use of income generated from Fish drying and trade? [Select one]

- No input or input in few decisions

- Input into some decisions
- Input into most or all decisions
- No decision made

11. In the past twelve months, did you yourself participate in Major household expenditures? (such as a bicycles, land, boda boda) [Select one]

- No [skip to question 12]
- Yes

11a. When decisions are made regarding Major household expenditures, who is it that normally takes the decision? [select multiple]

- Self [Skip to 11c]
- Spouse
- Other household member
- Other non-household member
- Not applicable

11b. How much input did you have in making decisions about Major household expenditures? [Select one]

- No input or input in few decisions
- Input into some decisions
- Input into most or all decisions
- No decision made

11c. To what extent do you feel you can make your own personal decisions regarding Major household expenditures if you want to? [Select one]

- Not at all
- Small extent
- Medium extent
- To a high extent

11d. How much input did you have in decisions on the use of income generated from Major household expenditures? [Select one]

- No input or input in few decisions
- Input into some decisions
- Input into most or all decisions
- No decision made

12. In the past twelve months, did you yourself participate in Minor household expenditures? (such as food for daily consumption or other household needs) [Select one]

- No [skip to question 13]
- Yes

12a. When decisions are made regarding Minor household expenditures, who is it that normally takes the decision? [select multiple]

- Self [Skip to 12c]
- Spouse
- Other household member
- Other non-household member
- Not applicable

12b. How much input did you have in making decisions about Minor household expenditures? [Select one]

- No input or input in few decisions
- Input into some decisions
- Input into most or all decisions
- No decision made

12c. To what extent do you feel you can make your own personal decisions regarding Minor household expenditures if you want to? [Select one]

- Not at all
- Small extent
- Medium extent
- To a high extent

12d. How much input did you have in decisions on the use of income generated from Minor household expenditures? [Select one]

- No input or input in few decisions
- Input into some decisions
- Input into most or all decisions
- No decision made

[END REPEATED QUESTIONS]

[SECTION B: NEW SET OF REPEATED QUESTIONS] [All questions are select one]

“Now I’d like to ask you about your household’s access to and ownership of a number of items that could be used to generate income.”

13. Does anyone in your household currently have any Agricultural land (pieces/plots)?

- Yes
- No [Skip to 14]

13a. Do you own any of this item?

- Yes, solely
- Yes, jointly
- No

14. Does anyone in your household currently have any Large livestock (oxen, cattle)?

- Yes
- No [Skip to 15]

14a. Do you own any of this item?

- Yes, solely
- Yes, jointly
- No

15. Does anyone in your household currently have any Small livestock (goats, pigs, sheep)?

- Yes
- No [Skip to 16]

15a. Do you own any of this item?

- Yes, solely
- Yes, jointly
- No

16. Does anyone in your household currently have any Chickens, Ducks, Turkeys, Pigeons?

- Yes
- No [Skip to 17]

16a. Do you own any of this item?

- Yes, solely
- Yes, jointly
- No

17. Does anyone in your household currently have any fishing equipment?

- Yes
- No [Skip to 18]

17a. Do you own any of this item?

- Yes, solely
- Yes, jointly
- No

18. Does anyone in your household currently have any Farm equipment (nonmechanized: hand tools, animal-drawn plough)?

- Yes
- No [Skip to 18]

18a. Do you own any of this item?

- Yes, solely
- Yes, jointly
- No

19. Does anyone in your household currently have any Farm equipment (mechanized: tractor-plough, power tiller, treadle pump)?

- Yes
- No [Skip to 19]

19a. Do you own any of this item?

- Yes, solely
- Yes, jointly
- No

19. Does anyone in your household currently have any Nonfarm business equipment (solar panels used for recharging, sewing machine, brewing equipment, fryers)?

- Yes
- No [Skip to 19]

19a. Do you own any of this item?

- Yes, solely
- Yes, jointly
- No

19. Does anyone in your household currently have any House or other structures?

- Yes
- No [Skip to 20]

19a. Do you own any of this item?

- Yes, solely
- Yes, jointly
- No

20. Does anyone in your household currently have any Large consumer durables (refrigerator, TV, sofa)?

- Yes
- No [Skip to 21]

20a. Do you own any of this item?

- Yes, solely
- Yes, jointly
- No

21. Does anyone in your household currently have any Small consumer durables (radio, cookware)?

- Yes
- No [Skip to 22]

21a. Do you own any of this item?

- Yes, solely
- Yes, jointly
- No

22. Does anyone in your household currently have any Cell phone?

- Yes
- No [Skip to 23]

22a. Do you own any of this item?

- Yes, solely
- Yes, jointly
- No

23. Does anyone in your household currently have any Other land not used for agricultural purposes (pieces/plots, residential or commercial land)?

- Yes
- No [Skip to 24]

23a. Do you own any of this item?

- Yes, solely
- Yes, jointly
- No

24. Does anyone in your household currently have any Means of transportation (bicycle, motorcycle, car)?

- Yes
- No [Skip to 24]

24a. Do you own any of this item?

- Yes, solely
- Yes, jointly
- No

[END REPEATED QUESTIONS]

[SECTION C: NEW SET OF REPEATED QUESTIONS]

“Next I’d like to ask about your household’s experience with borrowing money or other items in the past 12 months.”

25. Would you or anyone in your household be able to take a loan or borrow cash/in-kind from Non-governmental organization (NGO) if you wanted to? [select one]

- Yes
- Maybe
- No [skip to question 26]
 - a. Has anyone in your household taken any loans or borrowed cash/in-kind from Non-governmental organization (NGO) in the past 12 months? [select one]
 - Yes, cash
 - Yes, in-kind
 - Yes, cash and in-kind
 - No [skip to question 26]
 - I don’t know [skip to question 26]
 - b. Who made the decision to borrow from Non-governmental organization (NGO) most of the time? [select multiple]
 - Self
 - Spouse
 - Other household member
 - Other non-household member
 - Not applicable
 - c. Who makes the decision about what to do with the money/ item borrowed from Non-governmental organization (NGO) most of the time? [select multiple]
 - Self
 - Spouse
 - Other household member
 - Other non-household member
 - Not applicable

26. Would you or anyone in your household be able to take a loan or borrow cash/in-kind from Formal lender (bank/financial institution) if you wanted to? [select one]

- Yes
- Maybe
- No [skip to question 27]

a. Has anyone in your household taken any loans or borrowed cash/in-kind from Formal lender (bank/financial institution) in the past 12 months? [select one]

- Yes, cash
- Yes, in-kind
- Yes, cash and in-kind
- No [skip to question 27]
- I don't know [skip to question 27]

b. Who made the decision to borrow from Formal lender (bank/financial institution) most of the time? [select multiple]

- Self
- Spouse
- Other household member
- Other non-household member
- Not applicable

c. Who makes the decision about what to do with the money/ item borrowed from Formal lender (bank/financial institution) most of the time? [select multiple]

- Self
- Spouse
- Other household member
- Other non-household member
- Not applicable

27. Would you or anyone in your household be able to take a loan or borrow cash/in-kind from Informal lender if you wanted to? [select one]

- Yes
- Maybe
- No [skip to question 28]

a. Has anyone in your household taken any loans or borrowed cash/in-kind from Informal lender in the past 12 months? [select one]

- Yes, cash
- Yes, in-kind
- Yes, cash and in-kind
- No [skip to question 28]
- I don't know [skip to question 28]

b. Who made the decision to borrow from Informal lender most of the time? [select multiple]

- Self
- Spouse
- Other household member
- Other non-household member

- Not applicable

c. Who makes the decision about what to do with the money/ item borrowed from Informal lender most of the time? [select multiple]

- Self
- Spouse
- Other household member
- Other non-household member
- Not applicable

28. Would you or anyone in your household be able to take a loan or borrow cash/in-kind from Friends or relatives if you wanted to? [select one]

- Yes
- Maybe
- No [skip to question 29]

a. Has anyone in your household taken any loans or borrowed cash/in-kind from Friends or relatives in the past 12 months? [select one]

- Yes, cash
- Yes, in-kind
- Yes, cash and in-kind
- No [skip to question 29]
- I don't know [skip to question 29]

b. Who made the decision to borrow from Friends or relatives most of the time? [select multiple]

- Self
- Spouse
- Other household member
- Other non-household member
- Not applicable

c. Who makes the decision about what to do with the money/ item borrowed from Friends or relatives most of the time? [select multiple]

- Self
- Spouse
- Other household member
- Other non-household member
- Not applicable

29. Would you or anyone in your household be able to take a loan or borrow cash/in-kind from Group based microfinance or lending including VSLAs / SACCOs if you wanted to? [select one]

- Yes

- Maybe
 - No [skip to question 30]
- a. Has anyone in your household taken any loans or borrowed cash/in-kind from Group based microfinance in the past 12 months? [select one]
- Yes, cash
 - Yes, in-kind
 - Yes, cash and in-kind
 - No [skip to question 30]
 - I don't know [skip to question 30]
- b. Who made the decision to borrow from Group based microfinance most of the time? [select multiple]
- Self
 - Spouse
 - Other household member
 - Other non-household member
 - Not applicable
- c. Who makes the decision about what to do with the money/ item borrowed from Group based microfinance most of the time? [select multiple]
- Self
 - Spouse
 - Other household member
 - Other non-household member
 - Not applicable

30. Would you or anyone in your household be able to take a loan or borrow cash/in-kind from Table Banking if you wanted to? [select one]

- Yes
 - Maybe
 - No [skip to question 31]
- a. Has anyone in your household taken any loans or borrowed cash/in-kind from Table Banking in the past 12 months? [select one]
- Yes, cash
 - Yes, in-kind
 - Yes, cash and in-kind
 - No [skip to question 31]
 - I don't know [skip to question 31]
- b. Who made the decision to borrow from Table Banking most of the time? [select multiple]
- Self

- Spouse
- Other household member
- Other non-household member
- Not applicable

c. Who makes the decision about what to do with the money/ item borrowed from Table Banking most of the time? [select multiple]

- Self
- Spouse
- Other household member
- Other non-household member
- Not applicable

[END REPEATED QUESTIONS]

[SECTION D]

“Now I’d like to ask you about how you spent your time during the past 24 hours. We’ll begin from yesterday morning, and continue through to this morning. This will be a detailed accounting. I’m interested in everything you do (i.e. resting, eating, personal care, work inside and outside the home, caring for children, cooking, shopping, socializing, etc.), even if it doesn’t take you much time.”

31. How many hours do you spend...

- Sleeping & resting: _____ [box to enter a number, eg 2.5]
- Eating & drinking: _____ [box to enter a number, eg 2.5]
- Own business work: _____ [box to enter a number, eg 2.5]
- Farming/livestock: _____ [box to enter a number, eg 2.5]
- Fishing: _____ [box to enter a number, eg 2.5]
- Fish processing: _____ [box to enter a number, eg 2.5]
- Shopping/getting service (eg health service) : _____ [box to enter a number, eg 2.5]
- Weaving, sewing, textile care: _____ [box to enter a number, eg 2.5]
- Cooking: _____ [box to enter a number, eg 2.5]
- Domestic work (including fetching wood & water) : _____ [box to enter a number, eg 2.5]
- Caring for children/adults/elderly: _____ [box to enter a number, eg 2.5]
- Traveling and commuting: _____ [box to enter a number, eg 2.5]
- Watching TV/Listening to radio/ reading: _____ [box to enter a number, eg 2.5]
- Exercising: _____ [box to enter a number, eg 2.5]
- Social activities/hobbies: _____ [box to enter a number, eg 2.5]

p. Religious activities: _____ [box to enter a number, eg 2.5]

31. In the last 24 hours did you work (at home or outside of the home) more than usual, about the same as usual, or less than usual?

- More than usual
- About the same as usual
- Less than usual

[SECTION E]

“Now I’m going to ask you about groups in the community. These can be either formal or informal and customary groups.”

32. Is there a Agricultural / livestock/ fisheries producer’s group (including marketing groups) in your community?

- Yes
- No [skip to question 33]
- I don’t know [skip to question 33]
 - a. Are you an active member of this group?
 - Yes
 - No

33. Is there a Water users’ group in your community?

- Yes
- No [skip to question 34]
- I don’t know [skip to question 34]
 - b. Are you an active member of this group?
 - Yes
 - No

34. Is there a Forest users’ group in your community?

- Yes
- No [skip to question 35]
- I don’t know [skip to question 35]
 - c. Are you an active member of this group?
 - Yes
 - No

35. Is there a Credit or microfinance group (eg table banking) in your community?

- Yes
- No [skip to question 36]
- I don't know [skip to question 36]
- d. Are you an active member of this group?
 - Yes
 - No

36. Is there a Mutual help or insurance group (including burial societies) in your community?

- Yes
- No [skip to question 37]
- I don't know [skip to question 37]
- e. Are you an active member of this group?
 - Yes
 - No

37. Is there a Trade and business association group in your community?

- Yes
- No [skip to question 38]
- I don't know [skip to question 38]
- f. Are you an active member of this group?
 - Yes
 - No

38. Is there a Civic groups (improving community) or charitable group (helping others) in your community?

- Yes
- No [skip to question 39]
- I don't know [skip to question 39]
- g. Are you an active member of this group?
 - Yes
 - No

39. Is there a Religious group in your community?

- Yes
- No [skip to end]

- I don't know [skip to end]
- h. Are you an active member of this group?
 - Yes
 - No

The **Mother** recalling **her own** diet:

Food List	a. Time	b. Occasion	c. Food/Drink	d. Ingredients	e. How much [remember]

The **Mother** recalling **her husband's** diet:

Food List	a. Time	b. Occasion	c. Food/Drink	d. Ingredients	e. How much [remember]

The **Mother** recalling **her child's** diet:

Food List	a. Time	b. Occasion	c. Food/Drink	d. Ingredients	e. How much [remember]

2. Interviewing the Father

Father's Age:

The **Father** recalling **his own** diet:

Food List	a. Time	b. Occasion	c. Food/Drink	d. Ingredients	e. How much [remember]

--	--	--	--	--	--

The **Father** recalling **his wife’s** diet:

Food List	a. Time	b. Occasion	c. Food/Drink	d. Ingredients	e. How much of this i [remember to indicate

The **Father** recalling **his child’s** diet:

Food List	a. Time	b. Occasion	c. Food/Drink	d. Ingredients	e. How much of this i [remember to indicate

Appendix 5: The data recording form used by enumerators to collect data for the ‘dinner intake’ dataset.

Survey number: _____

Part 1: Fish purchasing and consumption habits			
1.1) How many days per month do you eat each food?	Omena: Fulu:	Catfish (Okoko): Nile Perch: Mudfish (mumi):	Farmed Tilapia: Lake Tilapia: Pond Tilapia: Eggs: Chicken: Red meat:
Part 1: Socio-economic and cultural factors			
2.1) Gender of respondent	♂ Male ♀ Female		
2.2) What tribe are you?			
2.3) What religion are you?			
2.4) Marital Status?	♂ Single	♂ Married	♂ Cohabiting ♀ Widowed/Divorced
Part 2: Wealth Index			
3.1) Where do you get your drinking water?	♂ I buy bottled water / get water piped to my house. ♀ I collect rainwater ♂ I buy it from delivery service vendors ♀ I carry it from the lake		
3.2) What is the primary fuel you use for cooking?	♂ Purchased charcoal ♀ Homemade charcoal ♀ Electric or gas stove ♂ Purchased firewood ♀ Collected firewood		
3.3) Which items do you own? [select all that apply]	♂ Motorcycle ♀ Refrigerator ♀ TV ♀ Smart phone ♀ None		
3.4) How many boats do you own?	No #:		
3.5) What type of lighting do you have in your house?	♂ Main-grid electricity ♀ Candles, paraffine, or wood fire ♀ Solar		
3.6) What material are your walls made of?	♂ Wood ♀ Mud ♀ Cement & mud ♂ Bricks ♀ Iron sheets		
3.7) What material is your floor made of?	♂ Wood ♀ Mud ♀ Cement ♀ Bricks/tiles ♀ Dirt		
3.8) Where do you go to the toilet?	♂ Private flush ♀ Private toilet (no flush) ♀ Private latrine ♂ Shared flush ♀ Shared toilet (no flush) ♀ Shared latrine ♂ Field/nature		
3.9) Do the women in your household get hair weaves regularly?	♂ Yes ♀ No		
3.10) Do your children go to local school or boarding school?	♂ Private boarding. ♀ Private day ♀ Public boarding ♀ Public day		

Part 3: Data to collect during cooking			
Food	Ingredients	Quantity	Notes

Part 3: Data to collect during cooking (write in the same order in which they are served)				
Family member, gender, & age	Food	Serving weight	Additional serving	Leftover serving
Were there any family members present who did not eat?		☐ Yes ☐ No	Reason:	
Was there leftover food?	☐ Yes ☐ No	Did everyone eat as much as they wanted?	☐ Yes ☐ No	Who did not get enough and why?

Appendix 6: Example of consent forms used during data collection. For illiterate participants or for participants unable to speak English, the consent forms were dictated to them in a language of the participants choosing.

Participant Consent Form

Research Project Title: Assessing the nutritional security of villages around Lake Victoria, Kenya

By signing below, I confirm that:
I confirm that I have read and understood the information sheet explaining the above research project and I have had the opportunity to ask questions about the project
I understand that my participation is voluntary and that I am free to withdraw at any time during the study, without giving a reason, and without any penalty. I understand that it will not be possible to remove any data I have already provided from the study.
I understand that my responses will be kept confidential and anonymous and I give permission for members of the research team to have access to my anonymised responses.
I agree to take part in this study.

Name of Researcher: Alexandra Pounds

Signature: 

Date	Name of Participant	Signature

Participant Information Sheet

Project Title: Assessing the nutritional security of villages around Lake Victoria, Kenya

Background & aims of project: My name is Alexandra Pounds and I research food security at the University of Stirling. In this project, I want to understand the food security of your community. The project is funded by the KTN Agrifood Africa Innovation Awards. We would like to invite you to take part in the research by completing a questionnaire.

Why have I been invited to take part? You have been invited because you live in a fishing village in the study area.

Do I have to take part? No. You do not have to take part. If you do decide to take part, you can withdraw your participation at any time without needing to explain and without penalty by advising the enumerator. If you withdraw, we will not collect any more data from you. However, any data collected up until the point that you withdraw will be kept and used in the data analysis. You will be given this information sheet and be asked to sign a consent form.

What will happen if I take part? You will need to complete the questionnaires, which will take about 30-45 minutes.

Are there any potential risks in taking part? There are no foreseeable risks in taking part.

Are there any benefits in taking part? There will be no payment for taking part in this project, but you will receive a gift (a bag of sugar) to thank you for your time.

Legal basis for processing personal data: As part of the project, we will be recording personal data relating to you. This will be processed in accordance with the General Data Protection Regulation (GDPR). Under GDPR the legal basis for processing your personal data will be public interest/the official authority of the University.

What happens to the data I provide? The research data will be kept anonymous and confidential. Only the enumerators and the researchers will have access to your data. We will not record your name or village – only your age and gender. As per university policy, the data will be kept for a minimum of 10 years in DataSTORRE.

Will the research be published? The research will be published in an academic journal and will be presented to the government as a short report. You will/will not be identifiable in any report/publication. If you would like to know the results, please provide your enumerator with your contact information so that we can contact you once the research is complete.

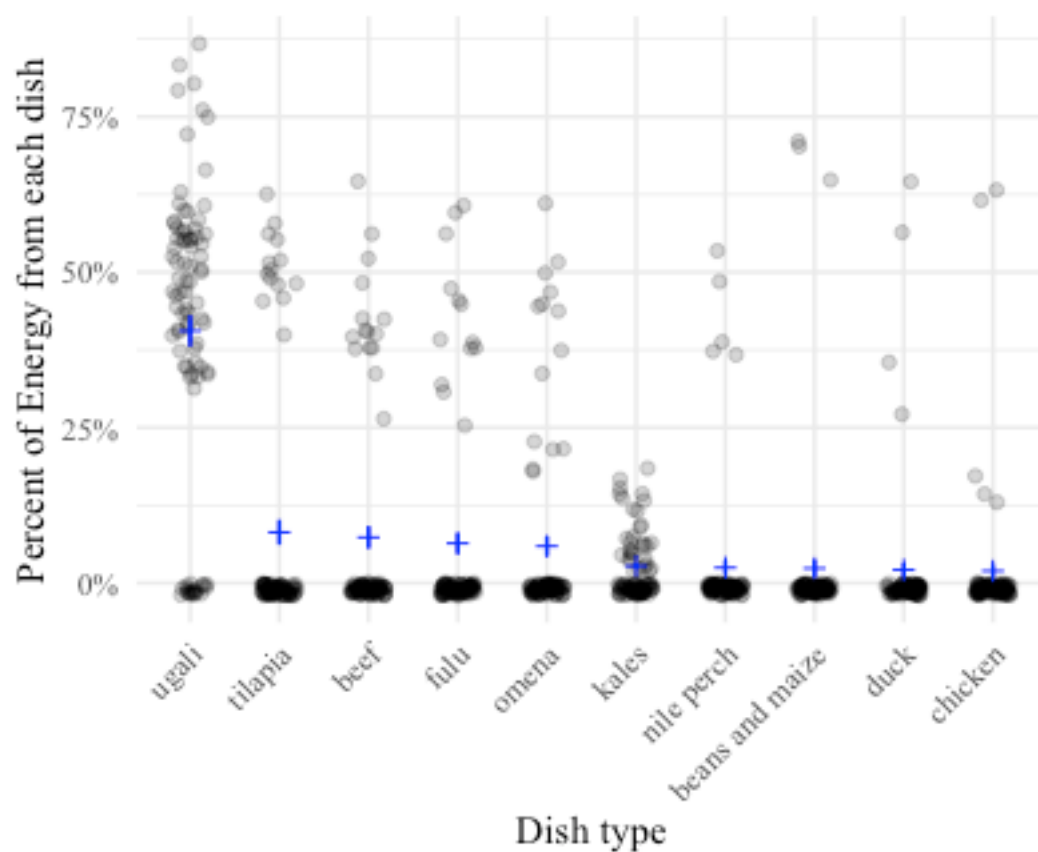
Who has reviewed this research project? The ethical approaches of this project have been approved via The University of Stirling General University Ethics Panel.

Your rights: You have the right to withdraw from this project at any time without giving reasons and without consequences to you. You also have the right to object to us processing relevant personal data however, please note that once the data are being analysed and/or results published it may not be possible to remove your data from the study.

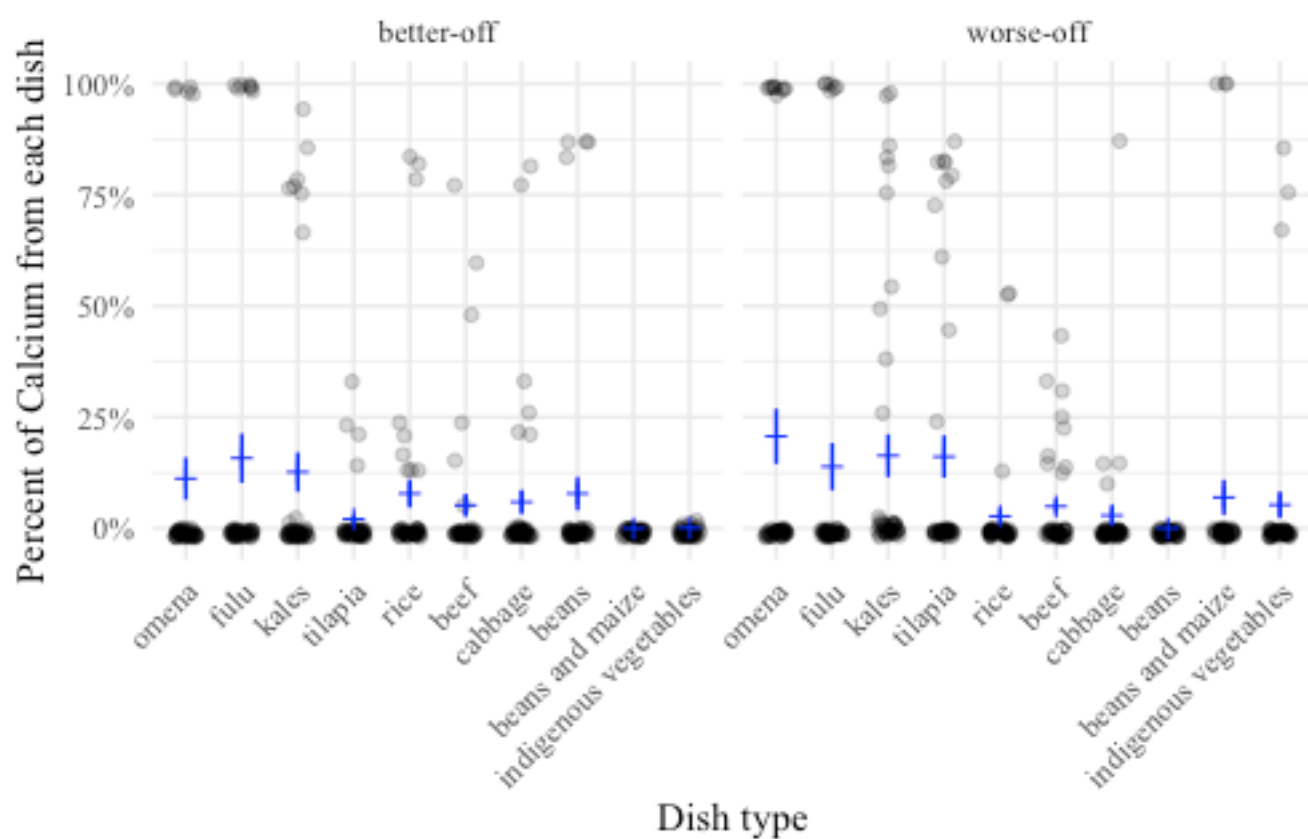
Who do I contact if I have concerns about this study or I wish to complain? Please contact Alexandra Pounds (alexandra.pounds@stir.ac.uk) or her supervisor Prof Dave Little (d.c.little@stir.ac.uk). In case you wish to complain, please contact the Head of Division Prof McKenzie (simon.mackenzie@stir.ac.uk). You have the right to lodge a complaint against the University regarding data protection issues with the Information Commissioner's Office (<https://ico.org.uk/concerns/>). The University's Data Protection Officer is Joanna Morrow, Deputy Secretary. If you have any questions relating to data protection these can be addressed to data.protection@stir.ac.uk in the first instance.

Thank you for your participation.

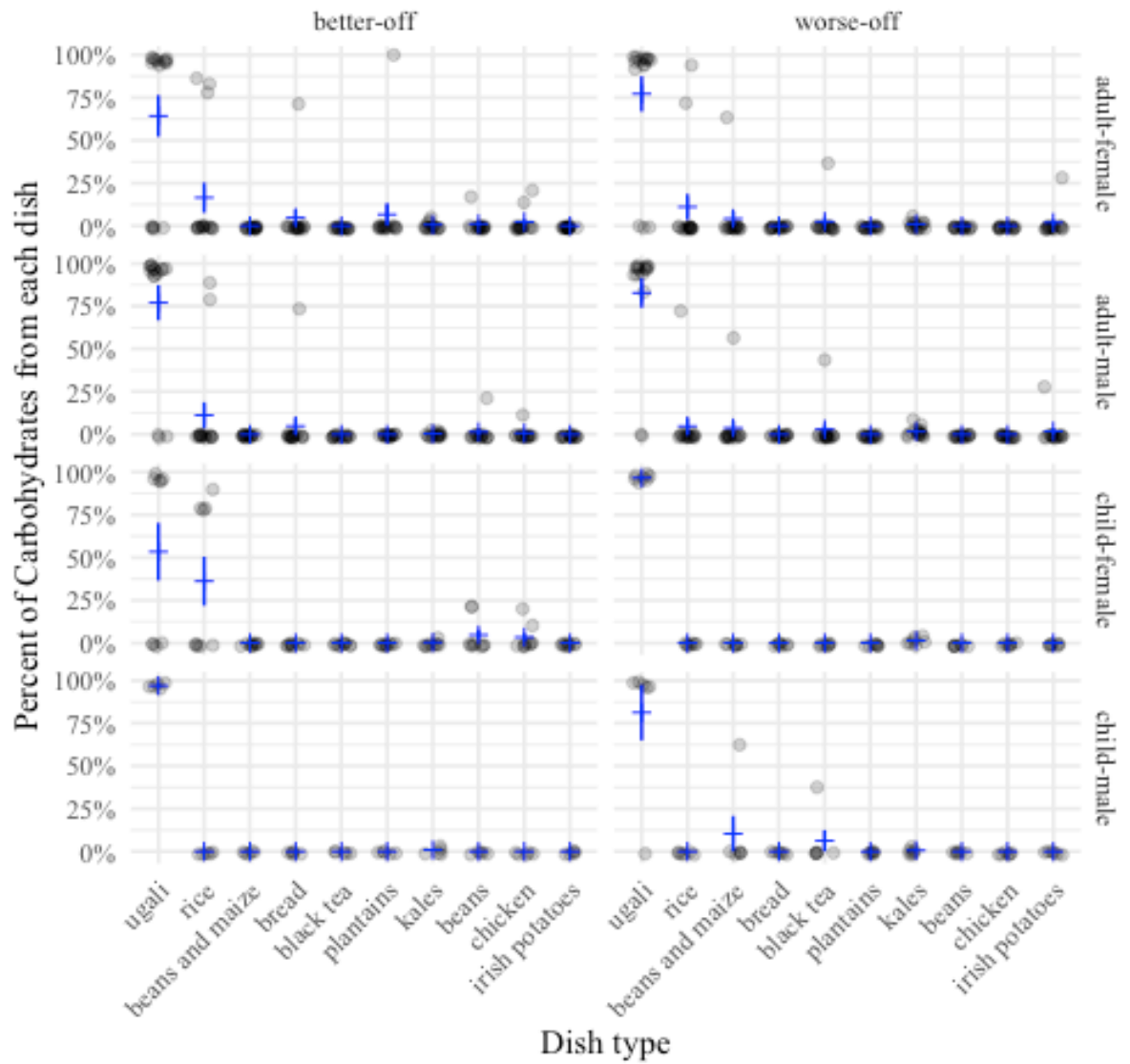
(a) Energy



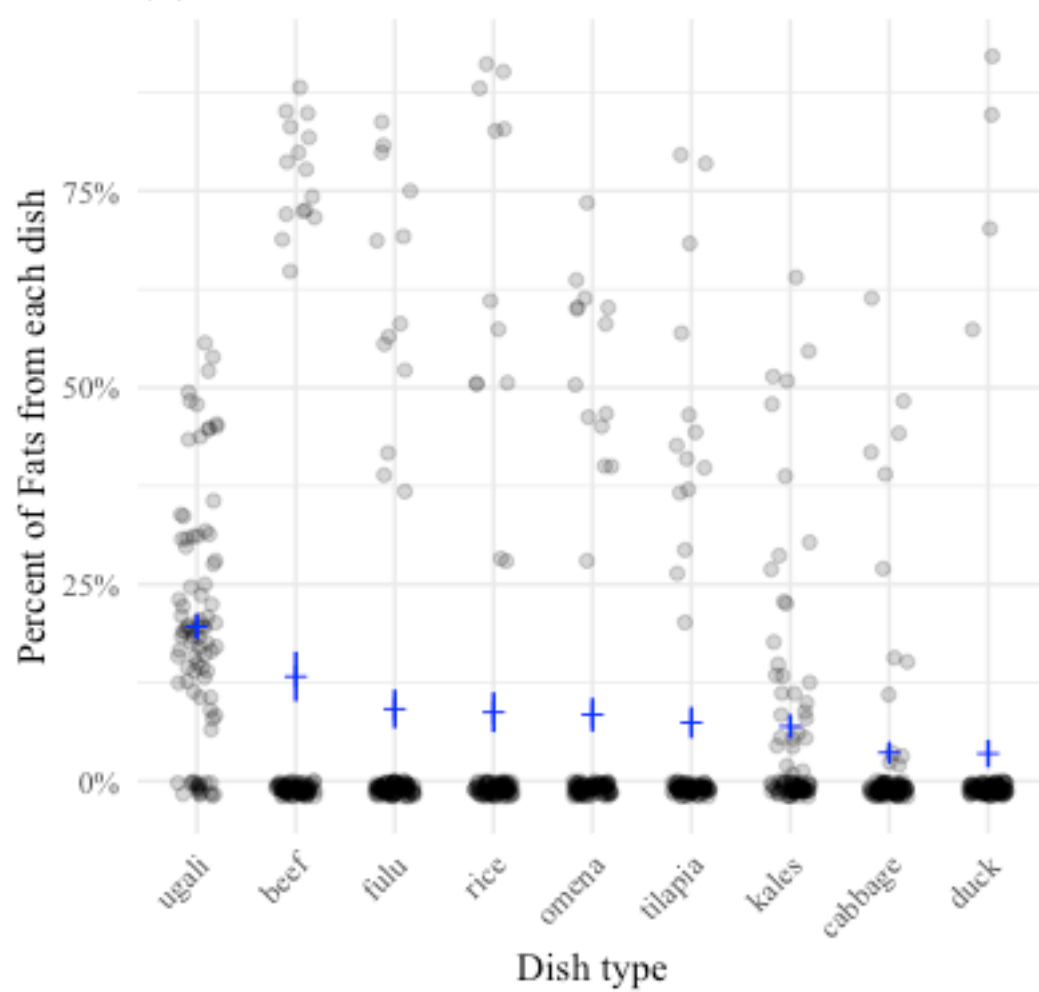
(g) Calcium



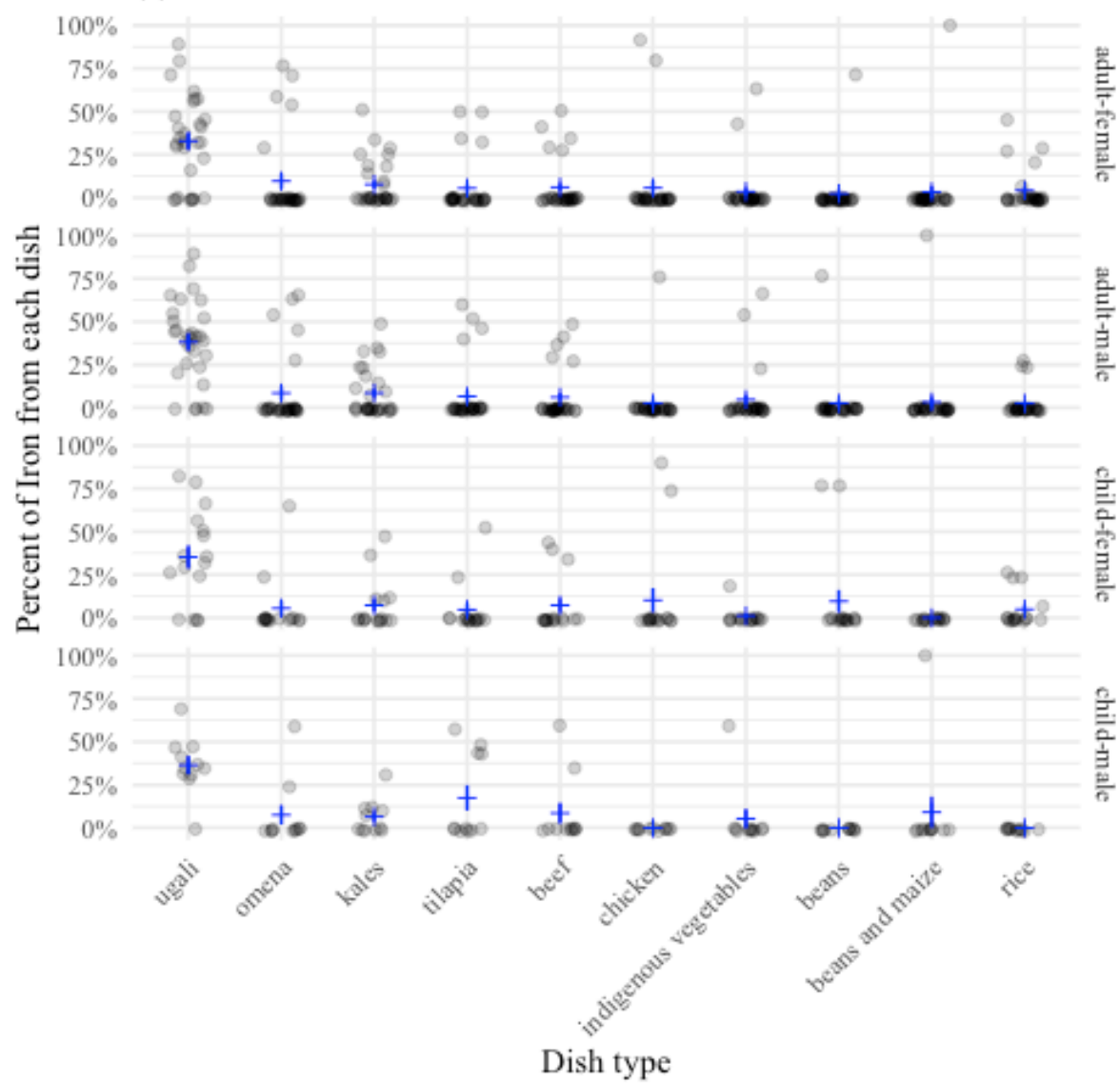
(b) Carbohydrate



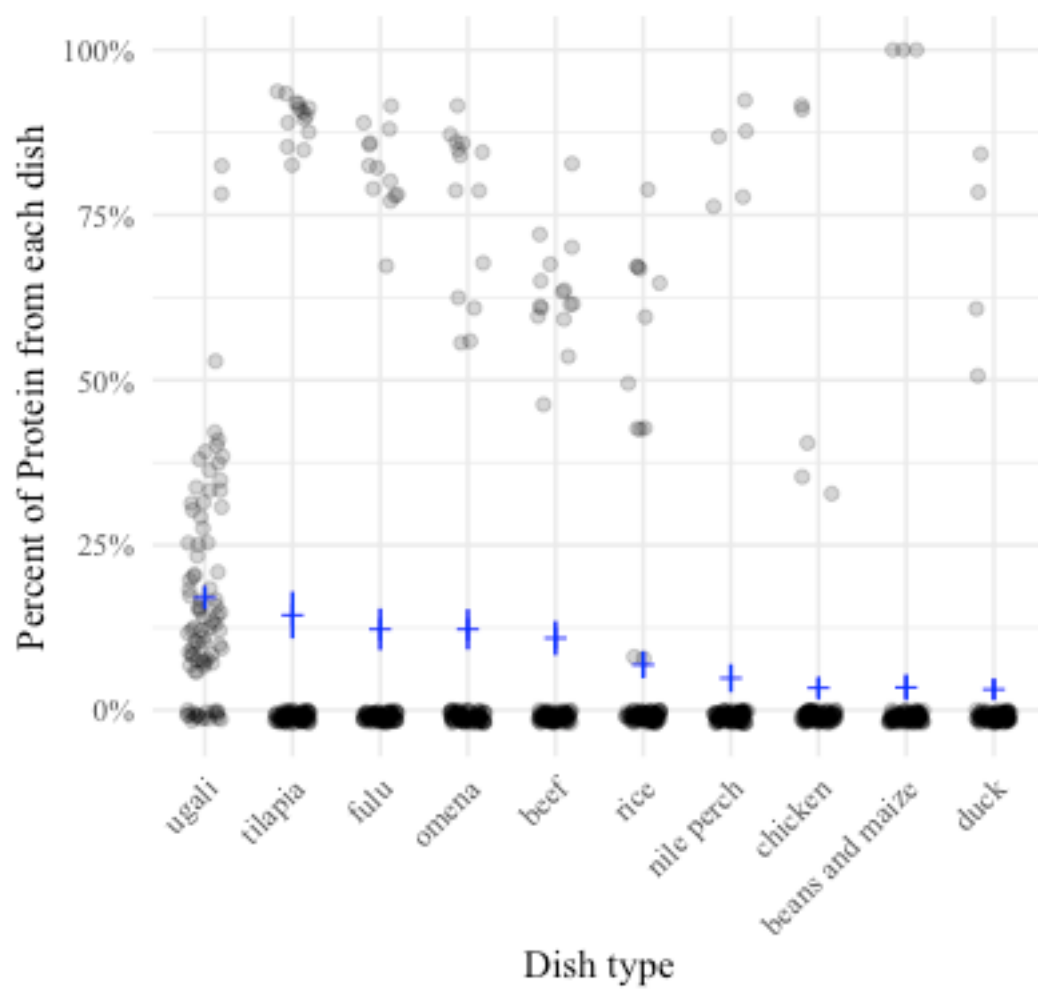
(d) Fats

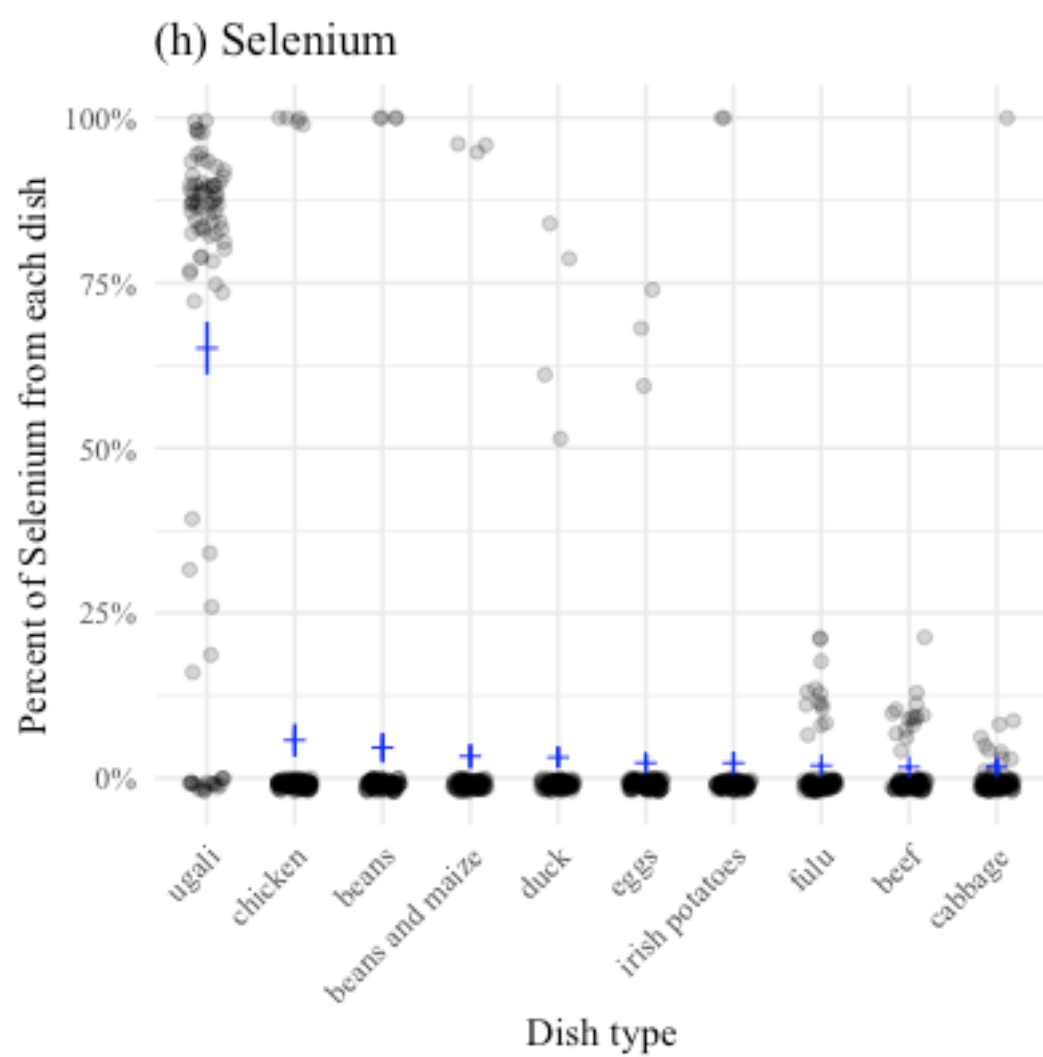


(f) Iron

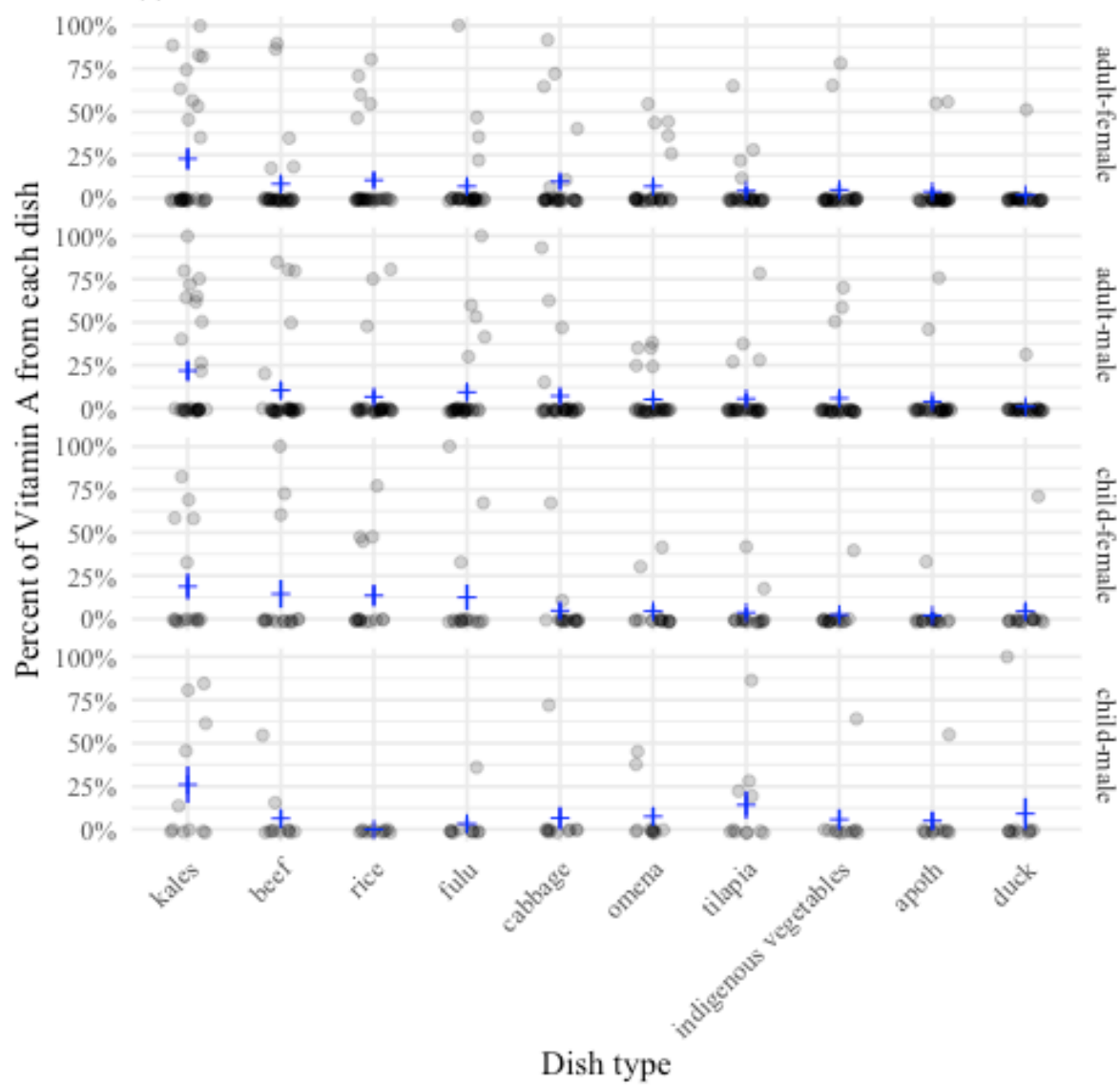


(c) Protein

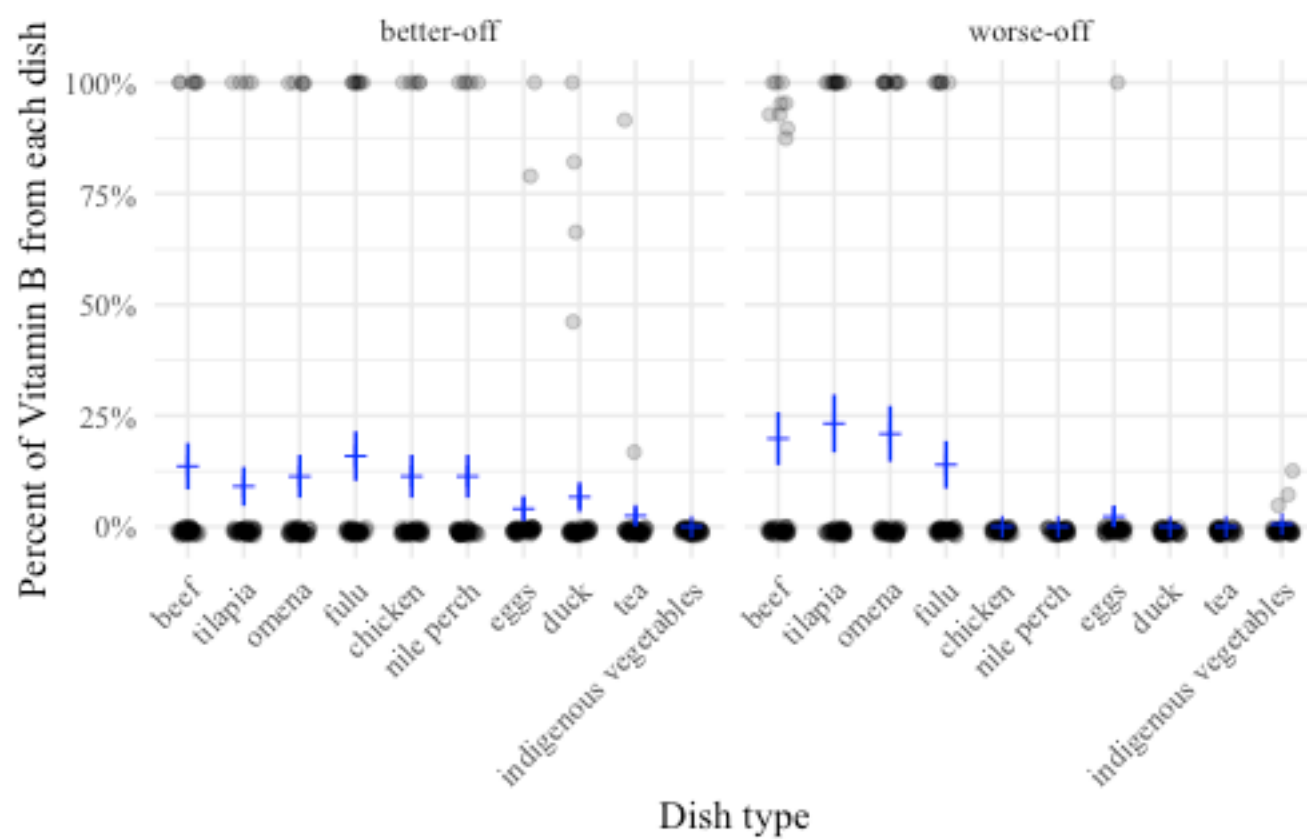




(i) Vitamin A



(j) Vitamin B12



(e) Zinc

