VALUE CHAIN MAPPING, MARKET EFFICIENCY, AND NUTRIENT COMPOSITION OF *Synodontis njassae* (Cuvier, 1816) (Pisces: Mochokidae) FROM LAKE MALAWI, MANGOCHI DISTRICT, MALAWI

MSc THESIS IN FISHERIES AND AQUATIC SCIENCES

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MZUZU UNIVERSITY

DECEMBER, 2025

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A THESIS SUBMITTED TO THE FACULTY OF ENVIRONMENTAL SCIENCES, DEPARTMENT OF FISHERIES AND AQUATIC SCIENCES, IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF A MASTER OF SCIENCE DEGREE IN FISHERIES AND AQUATIC SCIENCES

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DECLARATION

I hereby declare that this thesis, titled "Value chain mapping, market efficiency, and nutrient composition of *Synodontis njassae* (Cuvier, 1816) (Pisces: Mochokidae) from Lake Malawi, Mangochi District, Malawi," has been written by me and is a record of my research work. All citations, references, and borrowed ideas have been duly acknowledged. It is being submitted in partial fulfillment of the requirements for the award of the degree of Master of Science in Fisheries and Aquatic Sciences of Mzuzu University. None of the present work has been submitted previously for any degree or examination in any other University.

	19^{th} December, 2025
Gladson Chikolera	Date

CERTIFICATE OF APPROVAL

I, the undersigned, certify that this thesis is a result of the author's own work, and that to the best of my knowledge, it has not been submitted for any other academic qualification within Mzuzu University or elsewhere. The thesis is acceptable in form and content, and satisfactory knowledge of the field covered by the thesis was demonstrated by the candidate through an oral examination held on

________________________________ _________________________

Major Supervisor Date

Prof. Fanuel Kapute, PhD

ABSTRACT

Fisheries and aquaculture value chains are important sectors in supporting the livelihoods of societies, contributing about 28% of the dietary animal protein intake and 40% of the total protein supply of Malawians. This study evaluated the value chain map, market efficiency, and nutrient composition of *Synodontis njassae* from the south-east arm of Lake Malawi in Mangochi District, Malawi. The study adopted a stratified random sampling technique for value chain mapping and market efficiency survey. A total of 532 respondents (fishers, middlemen, processors, and retailers) were interviewed using a structured questionnaire at Makawa, Kela, Chimphamba, Namgoma, and Masasa fish landing sites in Mangochi. The standard analytical methods of the Association of Official Analytical Chemists were used to analyze nutrient composition. Fresh samples were locally purchased from fishers on their landing at the beach early in the morning for nutrient composition analysis. Results show that the value chain is predominantly male-dominated (57.7%), and the majority is of the youth age group (61%). The Shepherd efficiency model revealed that fish marketing activities among fish marketers are highly efficient, with a value higher (119.6%) than 100%. Moisture content was significantly higher in fresh fish (77.58±2.79) and lower in fried fish (3.47±0.1) (p=0.001). There was a significant decrease in protein between the processing methods, with the highest content in fresh fish, 23.49±0.47, and the lowest in smoked fish, 19.49±0.73 (p=0.00). Ash was significantly higher in smoked fish, 14.96±0.60, and lower in fresh fish, 13.25±0.47 (p=0.00). Potassium content was significantly higher in fried fish, 89.25±2.19, and lower in fresh fish, 73.28±1.86 (p=0.00). Iron content was significantly higher in fried fish, 3.88±0.01, as compared to fresh, 3.15±0.00, and smoked fish, 3.15±0.01 (p=0.00). The study concludes that the value chain is simple, involving fishers, middlemen, processors, retailers, and consumers. The marketing activities among the actors were efficient since the market efficiency value exceeded 100% (119.56%). The fish's nutrient composition constitutes essential macro and micro nutrients. The Department of Fisheries should encourage more players including value addition to strengthen the value chain; the Department of Fisheries should encourage more actors to join the business; there is a need to conduct a comparative study of *S. njassae* with other species.

Keywords: *Value chain, Market, Efficiency, Nutrient composition, Smoked, Fried, Synodontis njassae, Lake Malawi*

DEDICATION

I dedicate this piece of work to my wife, Evelyn, and my two children, namely Sophlet and Hastings, for supporting me throughout the study period.

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ACRONYMS

ANOVA	Analysis of Variance
AOAC	Association of Official Analytical Chemists
FAO	Food and Agriculture Organization
FISH	Fisheries Integration on Society and Habitat
GoM	Government of Malawi
ME	Marketing Efficiency
MZUNIREC	Mzuzu University Research Ethics Committee
NPC	National Planning Commission
SGD	Sustainable Development Goals
SOFIA	State of World Fisheries and Aquaculture
SPSS	Statistical Package for the Social Sciences

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CHAPTER 1: INTRODUCTION

1.1. Background

Fisheries and aquaculture value chains are very crucial pillars in sustaining the livelihoods of coastal communities around the world. According to FAO (2024), the value chains were instrumental in engaging a total of 61.8 million individuals in 2022, ranging from full-time, part-time, occasional, and unspecified work arrangements. Per capita consumption of aquatic foods increased from 9.1 kg in 1961 to 20.2 kg in 2020 globally. This increase is attributed to increased supplies, changing consumer preferences, technological advances, and income increases that have cumulatively framed the dynamic nature of fisheries and aquaculture. The African region saw a rise in the people employed by the fisheries and aquaculture value chains from 23.2 million people in 1995 to 33.6 million in 2022. Per capita fish consumption in Africa stands at 9.4 kgs, which is considered the lowest as compared to all other regions. In addition, aquatic animal food in Africa makes a significant contribution to animal protein supply, standing at about 18%.

In Malawi, the fisheries and aquaculture sectors employ over 1.6 million people in activities, including fish processing, boat building and engine repair, net manufacturing, and fish trade (GoM, 2025a). Fish is currently contributing 28% of total dietary animal protein intake for Malawians, and the per capita fish consumption is 9.6 kg per person per year (Tran et al., 2022). Lake Malawi has the largest number of freshwater fish species in the world, in the range of 800 - 1000 (Chavula et al., 2023). The total annual fish production has increased over the years. Fish landings across all species remained stable from 1976 to 2003 but increased by almost 200% starting in 2004, reaching its peak from 2012 to 2014 (Jamu et al., 2021). According to the GoM

(2024), fish production rose from 186,865.35 metric tons in 2022 to 202,045.61 metric tons in 2023.

The increase in production is attributed to the intensified exploitation of pelagic fish species. According to GoM (2024), *Engraulicypris sardella*, a prominent pelagic fish species, contributed 44.9% of the total landings in 2023, followed by *Copadichromis virginalis,* 8.1%. Jamu et al. (2021) reported that *E. sardella* dominated the biomass survey catch, contributing 70% and 62% to the total catch in 2014 and 2020, respectively. It was followed by *Copadichromis virginalis* and relatives (Utaka), *Lethrinops spp*., and allied genera juvenile (Kambuzi), *Rhamphochromis spp*. (Ncheni), and *Bathyclarias* and *Clarias spp*. (Mlamba).

Although the world's waters are stocked with millions of fish species, most commercial fish markets in the world concentrate on a few valuable ones, which makes most understudied or discarded. According to Love et al. (2015), 40-47% of all edible seafood becomes waste; 16-32% of seafood is lost in the form of wasted bycatch. Such bycatch and undervalued fish species can be integrated into the marketplace to contribute towards addressing the seafood consumption shortfall and poor health records. In developing countries, especially across Africa, the socio-economic dimensions of fish trade reveal enormous opportunities with continued challenges concerning low-value bycatch utilization (Thiago and Bunting, 2022). Across the Asia-Pacific region, and increasingly throughout Africa, bycatch and undervalued fish species open up valuable trade and processing opportunities, especially for women in post-harvest sectors (FAO, 2024). However, this opportunity is not realized due to deficiencies in market infrastructure, value addition technologies, and market information systems.

Value chain is defined as a structure of physical, economic, and social transactions between individuals and organizations engaged in the transformation of raw materials into finished products (Phiri et al., 2013). Value chain analysis creates an important framework for tracking the fish products from harvest to consumption and identifying opportunities for enhancing value addition and overall efficiency (Baihaqi et al., 2014). This kind of interdependence suggests that customer-related and supplier-related activities are interlinked and can have an effect on one another. Good governance, especially governmental enforcement of regulatory standards across the supply chain, is an important determinant of effective value chain operation (Hossain & Hossain, 2019).

Current value chain studies have focused on commercially high-value species, thus resulting in a significant knowledge gap regarding underutilized species. According to FAO (2024), there is considerable scope for the fishing industry to improve profitability by developing markets for consumable or commercially viable species, especially those that are part of sustainable and local catch. However, specific information is lacking with respect to the value chain structures, relationships among participants, and development potential of such underutilized species.

Within Malawi, most of the value chain analyses have focused on high-value commercial species. For example, Phiri et al. (2013) analysed the value chain of *Oreochromis spp*. (Chambo) of Lake Malawi, and Tsutsu and Singini (2021) analyzed the *Engraulicypris sardella* (Usipa) value chain. Chiwaula et al. (2012) analyzed the structure and profit margins of Lake Chilwa fisheries, and Manyungwa-Pasani et al. (2017) assessed women's participation in fish value chains at Lakes Malawi and Chilwa.

Market efficiency signals the economic performance of market channels of a particular product. Understanding market efficiency is essential for sustainable value chain development, as it directly impacts the benefit distribution among actors and the overall competitiveness of the product. While the analysis of market efficiency remains important, substantial knowledge gaps persist regarding the efficiency of markets for underutilized and bycatch species. Past studies have focused primarily on high-value commercial fisheries. For instance, Phiri et al. (2013) found that the Chambo (*Oreochromis spp.*) value chain in Lake Malawi was inefficient (market efficiency < 1.0), mainly because market margins and operational costs of wholesalers and retailers were high, along with the existence of multiple intermediaries between fishers, wholesalers, and retailers. In a similar vein, Tsutsu and Singini (2021) applied operational efficiency analysis in the case of *E. sardella* and found significant inefficiencies in that value chain.

Nutrient composition is another important aspect to consider in marketing any product. The analysis of nutrient composition provides an opportunity to establish a sustainable market channel for both agricultural and fishery resources. Although the nutritional importance of fish is well recognized, significant knowledge gaps remain regarding the nutrient composition of underutilized and bycatch species, especially those found in African freshwater systems. This lack of research poses a major obstacle to promoting these species and developing their markets. The absence of documented evidence on undervalued species' value chain, market efficiency, and nutritional value, it becomes challenging to encourage their consumption or to position them as viable substitutes for overexploited high-value species. The gap is particularly concerning in food-insecure settings, where underutilized species could play an important role in improving dietary diversity and nutrition security.

Synodontis njassae, locally known as Nkholokolo, is both a demersal and pelagic fish that remains underutilized in the catfish family and was previously considered a low-value fish and a bycatch in the trawl fishery. It contributed 3.2% of the total catch in the 2023 biomass trawl survey and was among the dominant fish species that contributed more than 1% in 2020 biomass trawl survey (GoM, 2024). Despite its abundance and potential contribution to food security, a research on the value chain structure, market efficiency, and nutrient composition of *S. njassae* remains limited from the scientific literature. This knowledge gap is particularly significant given the species' increasing visibility in catches and its potential role in alleviating pressure on overexploited high-value species. Understanding the current state of the *S. njassae* value chain, market efficiency, and nutritional value are essential steps toward informed decision-making about this species' role in Malawi's fisheries sector and food security strategy. Therefore, the current research aimed to investigate the value chain map, market efficiency, and nutrient composition of this underutilized deep-water species from Lake Malawi, Mangochi District.

1.2. Problem Statement

The decline in Malawi's fisheries resources primarily stems from the significant decrease in catches of fish species highly valued in commercial markets. Historically, the emphasis has been placed on commercially valued fish species such as *Oreochromis* (local: Chambo), which contribute significantly to the economic aspects of the fishery industry. However, the increased demand for fish has caused a significant shift in consumer perception, leading to an emphasis on the previously overlooked and less valuable fish species. These neglected species have not been subject to intentional exploitation and are now garnering significant attention in the context of fisheries management. This transformation is motivated by the urgent need to diversify the species targeted for harvest, as well as a growing awareness of the potential consequences of relying exclusively on commercially lucrative species.

Malawi is not the only country where the emphasis has shifted to underutilized species. Similar transformations have been observed globally, where targeted value chain development has unlocked the economic and social potential of previously neglected species. For instance, small pelagic fish like anchovies and sardinella were once thought to be low-value in West Africa, but their importance in regional trade and food security has increased thanks to investments in improved processing, more varied products, and more effective marketing techniques (FAO 2018). Ayilu & Appiah (2020) also found that value chain interventions frequently improve livelihoods, reduce post-harvest losses, and increase the visibility of underutilized species in both domestic and international markets. These international examples provide strong evidence that with targeted investment and value chain development, species like *S. njassae* can become pivotal for sustainable fisheries, economic diversification, and improved food and nutrition security in Malawi.

Among these less-exploited species, *S. njassae* stands out, particularly due to its habitation of deep waters. The demersal commercial trawlers in southern Lake Malawi, have previously considered this species as a bycatch and, in some cases, thrown away or given freely to people. Furthermore, unlike their commercially valued counterparts, these species have not been subjected to intensive fishing activities, and its continue to miss in the catch assessment survey reports. Despite recording a significant catch during recent trawl surveys of 2021 and 2023 *S. njassae* remains less exploited. This less-exploited status has brought them to the forefront of this paradigm shift, as they present an opportunity for sustainable fisheries management and ecological conservation. The study evaluated the value chain map, market efficiency, and nutrient composition of *S. njassae* from Lake Malawi, Mangochi District, Malawi.

1.3. Study Objectives

The main objective of the study was to evaluate the value chain map, market efficiency, consumer preferences, and nutrient composition of *S. njassae* in Mangochi.

1.3.1. Specific Objectives

i. To analyze the value chain map of *Synodontis njassae*

ii. To evaluate the market efficiency of *Synodontis njassae*

iii. To examine the nutrient composition of *Synodontis njassae*

1.3.2. Research questions

i. Who are the key players along the value chain of *Synodontis njassae?*

ii. How efficient are the market systems of *Synodontis njassae?*

iii. What nutrients are found in *Synodontis njassae?*

1.4. Justification of the study

Understanding the value chain map, market efficiency, and nutrient composition of *S. njassae* is very important for the sustainable management of the fishery and the conservation of the species. Previous studies have shown that analyzing the value chain in fisheries can lead to better resource management, improved market access, and increased economic benefits for local communities (FAO, 2018). In Southeast Asia, research has found that upgrading the value chain for fish like pangasius and tilapia helped these species become more competitive, increased exports, and reduced poverty among those involved in the value chain (Ababouch et al., 2023).

The research is also contributing to Sustainable Development Goals number 14.4 and 14.7. The target for SGD 14.4 is that by 2020, effectively regulate harvesting and end overfishing, illegal, unreported, and unregulated fishing, and destructive fishing practices, and implement science-based management plans, to restore fish stocks in the shortest time feasible, at least to levels that can produce maximum sustainable yield as determined by their biological characteristics. The target for SGD 14.7 is that by 2030, increase the economic benefits to Small Island Developing States and Least Developed Countries from the sustainable use of marine resources, including through sustainable management of fisheries, aquaculture, and tourism. In addition, the research aligns very well with Malawi 2063 agenda enablers 5 and 7, i.e., human capital development and environmental sustainability (NPC, 2020).

1.5. Ethical consideration

Consent was sought from the Mzuzu University Research Council (MZUNIREC) for clearance to carry out the research. All protocols were adhered to during the collection of fish samples for analysis. Consent was further sought from respondents during interviews. The research upheld the confidentiality that respondents deserve during the dissemination of the results.

CHAPTER 2: LITERATURE REVIEW

2.1. Fish value chain mapping

The term "value chain" refers to the entire set of processes that go into creating a product or service, from its inception to its various stages of production (which include both physical transformation and the input of different producer services), delivery to end users, and eventual disposal upon use (Kaplinsky & Morris, 2001). According to Phiri et al. (2013), it is “a structure of physical, economic, and social transactions between individuals and organizations engaged in the transformation of raw materials into finished products." Fishermen and crew members, intermediaries on the beach, wholesalers, middlemen in towns, retailers, and customers are all examples of value chain players in the fishing industry.

The value chain includes activities that occur in relationship with consumers and suppliers (Baihaqi et al., 2014). These activities are separate but are very dependent on one another. This indicates that customer-related activities (like marketing, sales, and customer support) and supplier-related activities (like purchasing and logistics) are linked and have an impact on one another. Modifications or enhancements made to one link in the value chain may have repercussions for other links.

Middlemen in a fish value chain can exert influence at various points within the chain. Fishers have very limited bargaining power because they do not have access to storage facilities, nor do they have the time or ability to store their fish for extended periods; therefore, they need cash quickly (Phiri et al., 2013). As a result, other actors in the market can take advantage of this situation and pay fishers less than the market would normally pay for their product. This results in an imbalance of power between the fishers and the middlemen, which creates information asymmetry within the supply chain where only the middlemen have access to market intelligence, while the fishers cannot be price makers but rather are price takers (Chiwaula et al., 2012).

The majority of women are concentrated at the processing and retail stages; however, they are largely excluded from participating at the highest levels within the value chain, including in strategically important roles such as those involved in large-scale fish trade and strategic decision-making (Manyungwa-Pasani et al., 2017). Culturally placed expectations, limited access to financial resources, and the burden of reproductive labour restrict women's mobility and the time that they have available for paid labour, thus keeping women involved primarily in low-profit, labour-intensive activities. Women's high involvement in the post-harvest phase of the value chain maintains the gender gap that is evident within the fisheries sector; therefore, new policies must support the advancement of women to break the cycle of gender inequality within the fisheries sector.

How actors interact with each other and their relationships affect the final outcome of market performance. In the case of Malawi fisher-middlemen relations, there are relationships between Fisher-middlemen based on originality, kinship, and geographical proximity (Phiri et al., 2015). This type of relationship creates Informal credit arrangements on the one hand, and it also develops dependency relationships. Such relations will provide the fisher with a financial security cushion during periods of lower catches, while at the same time causing the fisher to become trapped in a cycle of spatially-expansive, exploitation-based pricing, which exists throughout the fishing season.

The presence of several intermediaries in fishery value chains raises transaction costs and creates inefficiencies (Phiri et al., 2013). In terms of margins, every intermediary node takes a margin, which reduces producers' share, while at the same time causes an increase in consumer prices. As a result, the fisher will always receive the lowest percentage of the total amount of the fish sold on the market because of the cumulative sum of all the intermediaries' savings. In spite of the money taken away from them, the intermediaries provide important services for all fishers and consumers in the form of transportation to markets, market intelligence, risk tolerance, and the ability to aggregate small amounts of fish from various fishers.

The value chain's success and efficiency are highly dependent on the involvement of third-party stakeholders, with one of the most influential outside parties being the government. Government bodies enforce compliance with regulations throughout the entire value chain and extra-vital considerations in evaluating the performance of the value chain are provided by understanding how the value chain operates within the context of the specific government regulatory structure (Tsutsu and Singini, 2021; Manyungwa-Pasani et al., 2017). The governance component of a value chain is extremely critical in the creation and implementation of governance systems and affecting the way the value chains operate. Consequently, the results of the research revealed that for value chains to function effectively, governance systems must function properly; therefore, the government has an important role to play in ensuring the compliance of companies with applicable regulations. Additionally, the results of this research provide more support for studying the relationship between external stakeholders, legal frameworks, and the established values of the value chain. In other words, the study points out the need for consideration of governance systems, when trying to understand and optimize values in the broader context of the value chain.

The value chains encounter a wide range of challenges, including marketing and processing challenges as a result of a lack of storage facilities, low pricing of fish products as a result of the economic status of consumers, high transportation costs, and lack of storage facilities (Igwenagu et al., 2021). Tsutsu & Singini (2021) found that the *E. sardella* value chain actors experienced several challenges, including high post-harvest losses due to a lack of improved processing technologies and modern storage facilities.

The existing studies have demonstrated the fundamental components and challenges of the fish value chains; a limited number of species-specific studies indicate a critical research gap. The present study focused on evaluating the *S. njassae* value chain to inform targeted interventions and policy recommendations.

2.2. Market efficiency

Market efficiency is the ratio of marketing margin to marketing costs expressed as a percentage (Adedeji et al., 2019). Market efficiency in a value chain is categorized into operational and price efficiency (Fafchamps et al., 2005). Market operations that attempt to maximize the ratio of market input to outcome are referred to as operationally efficient (Mgale & Yunxian, 2020). It evaluates how well market organizations like manufacturers, distributors, or processors generate profits compared to their operational expenses. The analysis that is conducted in operational efficiency includes profit-to-cost ratio (profitability), market margins, and fisher share.

The concept of price efficiency is defined as how well the market system allocates resources and organizes the different stages of agricultural production and the marketing chain so that the market responds to what the consumer wants while also being efficient at using resources (Fafchamps et al., 2005). Price efficiency is about balancing the costs incurred during the agricultural production and marketing process against the prices that farmers receive for their products. Thus, market efficiency can be represented as how well the market performs in relation to value chain performance. A study by Panda & Sreekumar (2012) indicated that a market is efficient if it adds value to agricultural products, creates earnings for all market participants, improves customer satisfaction, and provides farmers with a larger percentage of the consumer price to promote production.

There are a number of different factors, aside from cost-margin calculations, that determine how effectively a market is operating. Market structure determines the level of market efficiency, as markets with competition enabled by a greater register of buyers and sellers will be able to create a more efficient outcome than those markets that are dominated by a small number of participants (Mgale & Yunxian, 2020). For example, in the chambo value chain, inefficiencies were created when wholesalers were too powerful, allowing them the ability to manipulate prices at their discretion (Phiri et al., 2013).

Access to information is critical for effective market operations. A lack of information regarding current market prices, quality standards, or consumer preferences results in suboptimal decision-making by all market participants, leading to lower total chain performance. In remote locations, for example, fishers face challenges with internet connectivity and other information communication technology related services and therefore experience 'information disadvantage' by accepting lower than average market prices based on their lack of knowledge regarding urban conditions or alternate selling options.

Infrastructure significantly impacts the overall efficiency of fishing operations. Enhanced cold storage capabilities contribute to reduced post-harvest loss rates, resulting in higher exchange quantities at the market level. Fish caught can be sold at higher prices upon reaching cold storage, rather than immediately offloading at lower prices because of oversupply. Moreover, efficient means of transporting fish to market reduce transaction costs, decrease travel time that may contribute to spoilage, and give fishers access to additional and more profitable markets further from their initial location; however, many African coastal communities lack the necessary infrastructure which directly affects their ability to maximize their operating capabilities throughout their value chain. For example, Tsutsu and Singini (2021) reported that there is more than a 30% post-harvest loss associated with Malawi's usipa value chain due to limited processing and storage capabilities.

Operational efficiency in the analysis of market efficiency helps value chain players to identify a market channel that gives maximum gains from the product (Romero & Wollni, 2018). Several studies have been conducted to evaluate the operational efficiency of agricultural products and characterize the factors influencing farmers (Safi et al., 2018). In the fisheries of Malawi, Phiri et al. (2013) evaluated market efficiency by applying the operational efficiency of the Chambo fishery. The study found that the market for chambo is not efficient since the index was less than one (ME<1). The inefficiency might be caused by the high market margins that resulted from the middlemen that were present between fishers and wholesalers, as well as between wholesalers and retailers, and from the high market costs that both wholesalers and retailers of fish incurred. The only way to lessen the inefficiencies in this situation is for fish retailers and wholesalers to focus on cutting their market expenses, which are comparatively higher than those borne by fishermen. Similarly, in the study by Tsutsu & Singini (2021), operational efficiency was applied to evaluate the market efficiency of *E. sardella* fishery in Lake Malawi.

Different metrics of effectiveness help evaluate how well a business' value chain operates, with these metrics having their own pros and cons. For instance, the Shepherd Index evaluates effectiveness by comparing marketing expenditures to the value added by a particular firm (or industry) along its value chain. For example, if an index of 100% indicates that marketing costs exceed added value that comes from production, this would indicate that marketing costs are not justified (Adedeji et al. 2019). In contrast, an index above 100% indicates that marketing costs are less than the added value generated through production; therefore, marketing has provided a return in excess of its cost. This metric is not without limitations. It does not reflect the extent to which value is shared between value chain participants. Thus, even though the Shepherd index may demonstrate an efficient value chain, producers may be disadvantaged by receiving a small fraction of the end value.

Marketing efficiency for agricultural or fishery products is determined by comparing the amount of money received by the producer/ or fisher to the final selling price (Affandi & Handayani, 2020). Other studies determine market efficiency by comparing the net marketing margin and marketing costs. When using the producer share, the marketing channels are said to be efficient if the ratio is greater than 50% and vice versa. When applying the ratio between marketing margin and marketing cost, the marketing channels are said to be efficient if the ratio is greater than 100%. Adedeji et al. (2019) in their study used marketing margin and marketing cost ratio. Findings indicated that fish marketing activities among fish marketers were highly efficient since the efficiency value was far higher than 100% (558.0%).

Market profitability and market effectiveness are critical for the sustainable selling of agricultural products like fish. For the nation to sustainably provide fish for human consumption through effective economic systems, nutrition, and well-being, effective and efficient market systems are necessary (Adedeji et al., 2019). Several studies (Bukenya et al., 2012; Osarenren & Ojor, 2014; Nsikan et al., 2015) describe low pricing, scarcity of fish, the selling of immature fish, insufficient funds, high transportation costs, insufficient storage facilities, and hefty levies and other taxes limit fish marketing. Low profit and efficiency were frequently the outcome of the product's nature and the absence of a well-organized market strategy, respectively.

The studies demonstrated that market efficiency has many sides encompassing operational and price efficiency dimensions. These studies have shown that achieving a 50% producer share threshold or a 100% marketing margin-to-cost ratio remains elusive for many fishing communities. The evidence from Malawi's *Oreochromis spp. and E. sardella* fisheries illustrates how structural inefficiencies particularly excessive middleman margins, high operational costs, and inadequate infrastructure systematically undermine market performance and fisher welfare. The present study zeroed in on the market efficiency of *S. njassae* to inform actors along the value chain on alternative channels to venture into to ensure the value chain is efficient.

2.3. Nutrient composition

The term "nutrient composition" describes the proportion composition of a fish's basic bodily components, which include water, protein, fats, carbs, and minerals. According to Ahmed et al. (2022), the chemical makeup of fish flesh predicts its quality, nutritional value, physiological state, and environment. In fish, approximately 66%–81% is water, 16%–21% is protein, 1.2%–1.5% mineral, 0.2%–25% fat, and 0%–0.5% carbohydrate.

Analyzing a fish's moisture content is one of the first and most fundamental steps in determining the amount of nutrients in its body (Ahmed et al., 2022). In addition, Barua et al. (2012) found that moisture levels in food can accurately predict its calorie, protein, and fat content. As such, fish with less moisture provides more protein and fat in addition to having a higher calorie density. The second most important component of fish's nutrient composition, after moisture, is protein because it contains essential amino acids (EAA), which are necessary for fish maintenance, development, reproduction, vitamin synthesis, and high digestibility (Ahmed & Sheikh, 2017). The third most significant component of fish muscle is fat which is involved in numerous critical processes, such as the creation of cell and tissue membranes, and is also a significant source of metabolic energy (Ahmed et al., 2022). Protein, fat, and water content of fish are important to consumers, scientists, and manufacturers from many aspects, including nutritional value, seasonal variations, and considerations regarding processing (Boran & Karaçam, 2011). Other studies have shown that most processing methods, especially those involving addition of heat, affect the chemical composition of the processed fish by altering its nutrient levels (Lipato & Kapute, 2017). Katola & Kapute (2016) found that crude protein content of *Oreochromis mossambicus* samples was significantly higher in solar tent-dried fish compared to traditionally smoked fish. Kaponda & Kapute (2017) found that *Barbus paludinosus* smoked using an improved smoking kiln retained more crude protein compared to the samples traditionally smoked.

Although value chain mapping, market efficiency, and nutrient composition studies are usually treated as distinct areas of inquiry, it is only by bringing the dimensions together under one framework that such fish species are analysed effectively. Value chain analysis explains actors, the transformations the product undergoes, and coordination mechanisms linking various stages. Market efficiency analysis looks at whether such activities generate enough returns in relation to costs while gains are appropriately distributed among participants. Nutrient composition analysis determines nutritional potential and how handling or processing practices affect that value from catch to consumption.

Applying this integrated perspective to *S. njassae* allowed identification of how a species, commonly considered of low value or bycatch, could become a significant source of nutrition and income. Even with strong nutritional characteristics, a species will remain underutilized if value chain functions are weak, if markets function inefficiently, or its attributes are poorly recorded. Alternatively, even efficient value chains cannot generate demand for a species that provides little nutritional benefit or does not appeal to consumers. Sustainable development of markets for underutilized species requires congruence among all three analytical components.

This integrated view is similarly crucial to the formulation of efficient policies and interventions. For example, value chain analysis might point to constraints in infrastructure, but without information on market performance and nutritional value, it is difficult to assess whether removing those constraints would have significant benefits. On the other hand, nutritional results may provide support for promoting *S. njassae* consumption, but such efforts will not be successful if the value chain is disorganized or if inefficiencies place prices out of the reach of consumers.

2.4. The conceptual framework

The model outlining this research (Figure 1) shows how three key dimensions, which are value chain structure, market efficiency and nutrient composition, affect utilization of *S. njassae* and its contribution to improving food security in Mangochi district. The model assumes that *S. njassae*, an underutilized resource, may only contribute significantly to improved nutrition and support rural livelihoods when it has an effective value chain, a functioning market, and its nutritional benefits are appropriately documented. If *S. njassae* is to be moved from a low-value bycatch to being treated and valued as a food resource, it is necessary that each of these dimensions be strengthened.

2.4.1. Value Chain Components

The term 'Infrastructure' as used in this study covers the physical and institutional infrastructure that supports the distribution of fish from the point of harvest through to completion of sales to the consumer. The physical infrastructure landing sites, cold storing plants, ice making plants, drying and smoking houses, methods of transport, trucks and fuel supply represents the facilities required for transporting fish from producer to market place. The institutional Infrastructure includes systems for the dissemination of fish market information, regulation and quality assurance systems, food safety systems, inspecting and grading systems, financial services that aid to the facilitation of transactions and accessibility to credit.

Proper infrastructure creates lower transaction costs, protects product quality, increases efficiency and increases the reach of an economic value chain across borders. On the contrary, if physical infrastructure does not process properly due to the absence of legitimate facilities; the Producer will incur delays, pay higher prices for product losses, and suffer from market access barriers in addition to geographical constraints that must be addressed in order to enable fresh fish to be effectively marketed. For instance, with *S. njassae*, the absence of cold storage facilities at landing sites causes fishermen to sell their fish for immediate disposal at very low prices because of the limited amount of time that fresh fish can remain viable after being harvested; moreover, a poor road infrastructure limits their ability to transport their products to faraway markets and to find demand.

All those involved in harvesting, processing, handling and marketing *S. njassae* are part of the value chain. Fishers generally catch them as bycatch; typically, fishers catch them using a variety of fishing methods (e.g., chilimira or kambuzi, trammel nets, gill nets, trawling). Middlemen or aggregators usually purchase all catches, group and consolidate them into bulk shipments, provide immediate cash payment, and absorb risk from spoilage and market price fluctuations. Through their work, processors create value using different methods to prepare fish for preservation, storage, and further marketing, such as smoking, drying, or frying.

Retailers (e.g., market vendors, mobile sellers, roadside sellers, etc.) connect the processor to the consumer by selling the product to the consumer. Retailers provide the services of displaying products, short-term storage, and marketing activities to all retailers. In addition to all value chain actors, there are support service actors (boat builders, gear manufacturers, fuel suppliers, transporters, financial institutions, and regulatory agencies) that help provide inputs and oversight to the value chain. The relationships and coordination between all actors contribute to the ability for fish to move effectively through the value chain, the degree to which value is added, and how the benefits of fish will be distributed among the actors.

2.4.2. Market Efficiency

Market efficiency is the degree to which a market allows firms to operate competitively and interactively, while functioning normally; in competitive markets there are always a number of buyers and sellers operating within them, entry barriers are low for both buyers and sellers, prices can be easily accessed, there is transparency over quality of products being traded, Trade is not dominated by just one or a few actors; as a result competition amongst buyers creates stronger bargaining power for farmers, and reduces dependence on a single buyer, competition for the sale of processed products creates conditions for improving and innovating new processed product offerings by processors, the consumer benefits by paying less for processed products, having a wider selection of processed products to choose from, and being able to react quickly to changing purchasing patterns.

In order for *S. njassae* to continue to increase its market efficiency, *S. njassae* needs to expand its buyer base beyond its current limited number of buyers, remove existing constraints that prevent new traders from entering the marketplace, establish grading or quality standards that allow for Price differentiation, and developing polices that do not unintentionally benefit an established trader by creating market concentration for them; The fact that there are so few people trading is an indication that there is insufficient competition within *S. njassae* to fully develop the Market. A lack of competition means that markets are not able to develop effective marketing techniques for all *S. njassae* products thus results in losing either business or value for their products.

2.4.3. Nutrient Composition

To develop the full potential of *S. njassae* as a food source, it is important to identify its nutritional characteristics (i.e., protein, fat, minerals). Without scientific evidence for the nutritional value of *S. njassae*, this species is undervalued as a potential source of micronutrients and dietary variety. The nutritional profile of *S. njassae* can provide support for development of value chains by providing evidence-based marketing messages to consumers, providing the basis for policy/investment decisions related to building value chains, providing guidance to processors on how to maximize the preservation of nutritional quality of *S. njassae*, and allowing traders to differentiate *S. njassae* in the market based on the nutrient profile.

Synodontis njassae is very commonly processed through smoking and frying. It is, therefore, critical to understand how different types of processing might affect nutritional retention. If some methods cause large losses of nutrients, promoting alternative methods or encouraging fresh consumption of *S. njassae* may be beneficial. If processing preserves nutrients or concentrates them, this information could be used to provide further support for investment in processing methods/technologies and in training.

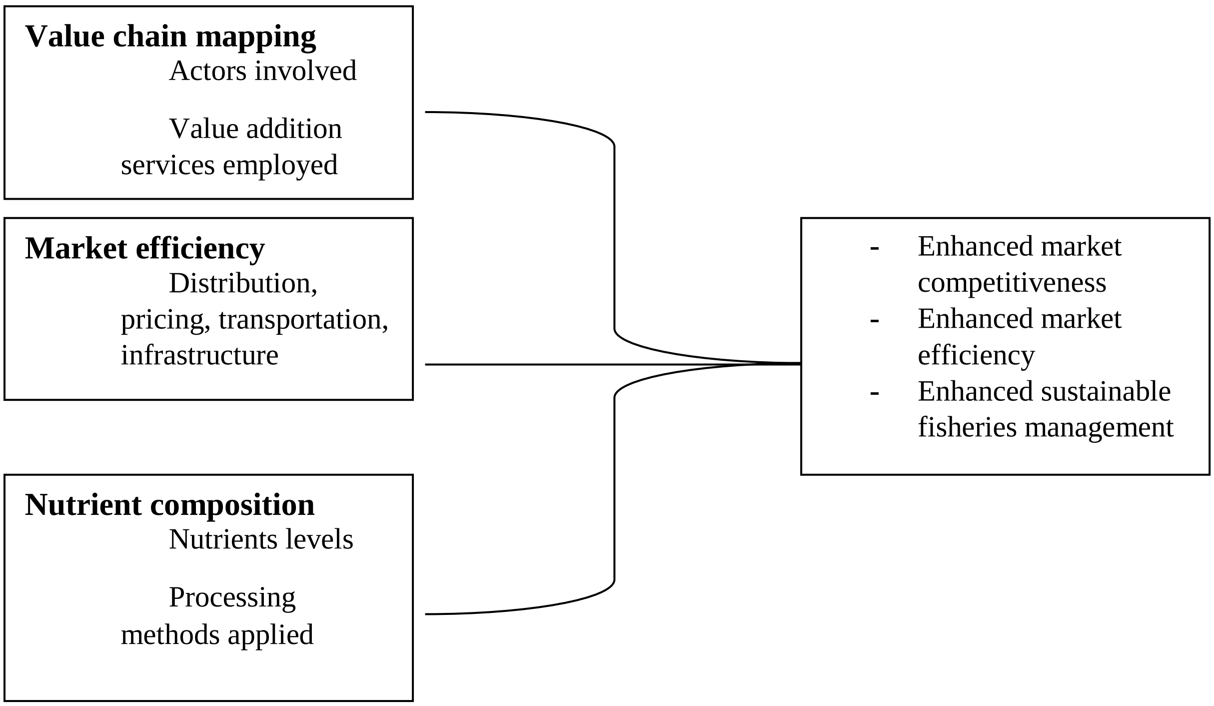

Figure 1 The Conceptual framework used in the study

CHAPTER 3: MATERIALS AND METHODS

3.1. Study Area

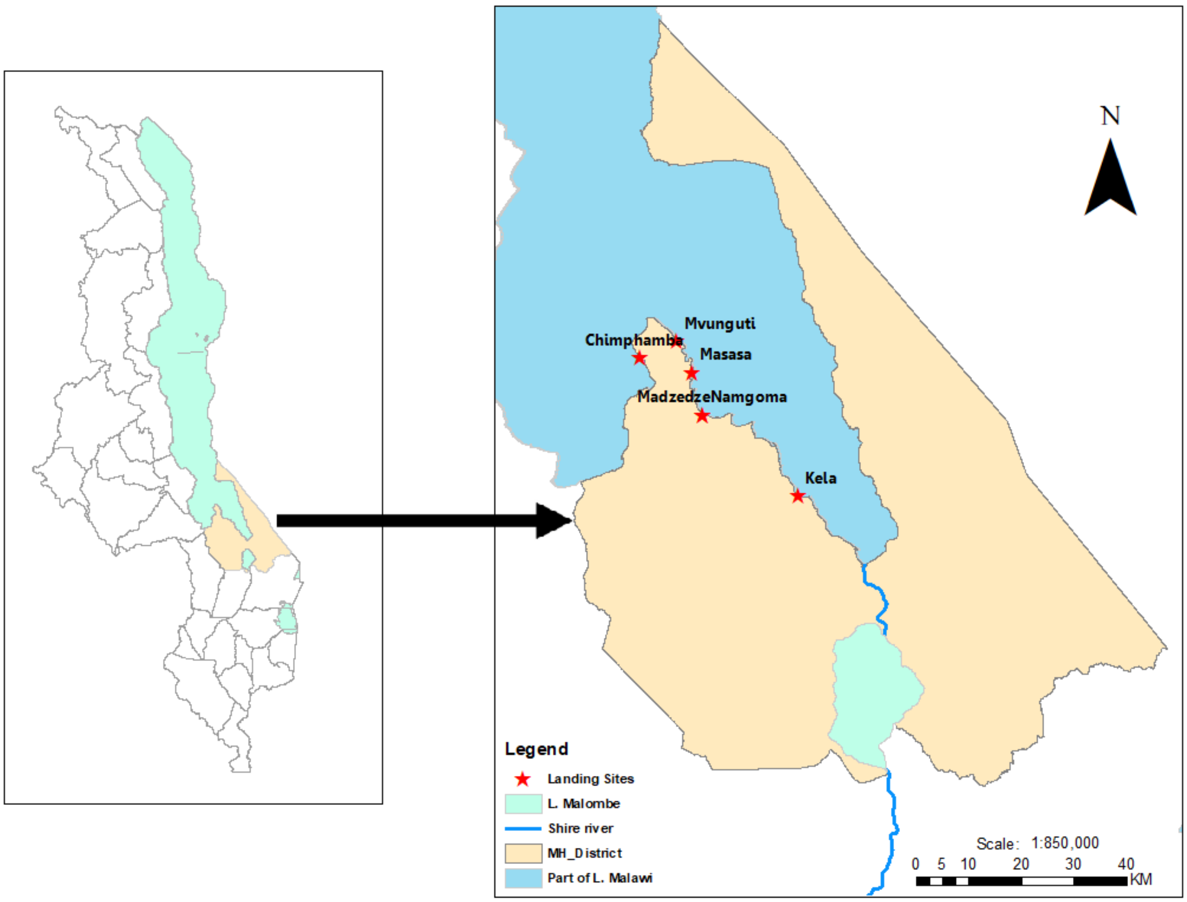

Figure 2 Map of south-east arm of Lake Malawi showing Mangochi District, Malawi (Generated in ArcGIS)

The study was conducted in strata 2.3 and 3.1N, namely Madzedze and Msaka, respectively in Mangochi. Mangochi is in the southern region of Malawi at -14.486173 latitude, 35.253304 longitude, which has a population of 1,148,794 people sitting on 6729 sq. km of land (National Statistical Office 2019). According to GoM (2025b), the 2024 annual frame survey, over 25,262 people are directly employed in the fisheries sector, including gear owners and crew members.

3.2. Research design

3.2.1. Sampling

Stratified random sampling was used to sample the respondents for the survey. The sample was stratified according to the roles the respondent play along the fish value chain. Therefore, the study reached out to fishers, middlemen, processors, and retailers to map and quantify market efficiency of the value chain.

3.3. Sampling framework and methods

The sample of 384 was randomly selected from five fish landing sites in the South-East Arm of Lake Malawi. This sample included 96 fishers, 96 middlemen, 96 processors, and 96 retailers. The study further engaged 7 key informants from different designations (3 gear owners, 2 fisheries officers and 2 beach village committee chairs) . The sample size was arrived at by using the formula below;

$nr=p(1- p)(Z/\mathcal{E})^2$ ……………………………………………………..Equation 1

Where nr = sample size and z = value from the standard normal distribution reflecting the confidence level (z = 1.96 for 95% level of confidence) of unknown population proportion (p), Ɛ is the margin of error. The p = 0.5 value was used (assuming maximum heterogeneity). The margin of error (Ɛ = 0.05 for maximum variability) was used to calculate a statistically representative sample.

3.4. Data Collection

3.4.1. Value chain mapping

Figure 3 Kela fish landing site, south-east arm of Lake Malawi, Mangochi

Qualitative data was collected for players involved in the value chain. A questionnaire was used during the survey. Key activities done by the actors were collected to map the flow of the product.

3.4.2. Market efficiency analysis

Quantitative data was collected for actors in the value chain of *S. njassae*. A questionnaire was used to collect fishing costs, costs for fish processing and transport, quantities, market strategies, purchase price, total revenues, market tax, and challenges faced by actors to understand the market performance and proposals for improving the value chain.

3.4.3. Nutrient composition analysis

Fifty freshly caught samples of *S. njassae* were purchased from Lake Malawi in Mangochi district, namely Madzedze and Msaka, respectively in Mangochi. The samples were transported in a cooler box to Lilongwe University of Agriculture and Natural Resources (LUANAR) laboratory. The following materials and equipment were used; drying oven, distillation apparatus, muffle furnace apparatus, extraction thimbles, spatulas, analytical balance, grinding mill, Kjeldahl apparatus, soxhlet extractor apparatus, crucibles, Petri dishes, flasks, cotton wool, gloves, filter papers, microwave plasma absorption emission spectrophotometer (MPAES), hotplate, beakers, distilled water, litmus paper, methyl red indicator, petroleum ether, ethanol, sodium hydroxide, sulphuric acid, boric acid, bromocresol green indicator and kjeldahl catalyst tablets.

3.4.3.1. *Sample processing*

Two commonly practiced processing techniques were applied i.e., smoking and deep frying. The fish were washed, partially sun dried then smoked using a traditional smoking kiln and the other batch of the sample was deep fried in edible cooking oil. Fish were smoked using traditionally constructed smoking kiln commonly used by the fish processors in the area.

Figure 4 Freshly caught *Synodontis Njassae*

Figure 5 Frying of *Synodontis njassae*

Figure 6 Smoking of *Synodontis njassae* on traditional smoking kiln

3.5. Data Analysis

3.5.1. Value chain mapping

Porter (2008) value chain mapping and analysis model was used to analyze the data collected. Each stage of the *S. njassae* chain was mapped to corresponding primary activities, including harvesting, handling and storage, transportation and distribution, and marketing. Second, the study identified support functions such as regulatory mechanisms, access to finance, infrastructure availability, and technology adoption that influence performance at each stage. The model guided the identification of inefficiencies, coordination gaps, and opportunities for upgrading. This structured approach ensured that both tangible processes (e.g., storage facilities) and enabling conditions (e.g., institutional support, access to information) were systematically analysed.

3.5.2. Market efficiency

Economic data on quantities, units' price, market strategy, purchasing price, selling price, processing costs, storage costs, transportation costs, and market fees were used to determine operational efficiency. Both data for fixed costs and variable costs were collected from actors. Variable costs included all the costs that change according to the product handled, such as transport, fuel, hiring of the processing materials, labor, marketing, storage, and others.

Market efficiency (ME) is a measure of market performance, and is defined as the movement of farm produce from producers to consumers at the lowest cost consistent with the provision of services desired by consumers.

Efficiency ratio is given as:

a. $TR/TVC > 0$ = it is operational efficiency ………….. Equation 2

b. TR/TVC < 0 = it is operational inefficiency ………….. Equation 3

Where;

TR is total revenue

TVC is total variable cost

Shepherd efficiency used by Adedeji et al. (2019) was adopted in this study to evaluate the market efficiency as follows:

Marketing cost

$TC = C_P + \sum Mci$……………………………………………………………. Equation 4

Where:

i=1

TC = Total Cost of Marketing

Cp = Producer cost of marketing

Mci = Marketing cost by the ith trader

Marketing margin:

AM = Psa – (Pba + Mc) ………………………………………………………Equation 5

Where;

AM = Absolute Margin

Psa =Selling price

Pba = Buying price

Mc = Marketing cost

Producer share in the consumer's price

Ps = (Pp/Pr)x100 ………………………………………………………………….. Equation 6

Where;

Ps = Producer share in the consumer's price

Pp = Producer's price

Pr = Retail price or final consumer price

Market efficiency with Shepherd Index

ME = Pr/(TC+AM) ………………………………………………………………… Equation 7

Where;

Pr = Retail price or final consumer price

TC = Total cost of marketing

AM = Absolute margin

ME = $\frac{Value\ added\ by\ marketing}{Marketing\ cost\ or\ cost\ of\ marketing\ services}\ x\ 100$ ….Equation 8

3.5.3. Nutrient composition

Fresh and processed samples were analyzed for their nutrient composition using the standard analytical methods of the Association of Official Analytical Chemists (AOAC, 2005). Nutrient analysis is a quantitative method of determining the macronutrients and microelements in food. This includes macronutrients (crude protein, crude fat, ash, and moisture) and minerals (iron, zinc, and potassium).

3.5.3.1. Determination of crude protein content

To determine the Protein content of the fish samples micro-kjeldahl method was used which involves three steps digestion, neutralization, and titration. This method involved the conversion of organic nitrogen to ammonium Sulphate in digestion with concentrated sulphuric acid in a micro kjeldahl flask. The digest was diluted, made into alkaline with sodium hydroxide, and distilled. The liberated ammonia was collected in a boric acid solution and will be determined titrimetrically. The percentage of protein in the sample was calculated by the following equation:

Percentage (%) of protein = (c-b) × 14 × d × 6.25/a × 1000 × 100 ……………….Equation 9

where, a = Sample weight (g); b = volume of NaOH required for back titration and neutralization 25 ml of 0.1 N H_2SO4 (for sample); c = volume of NaOH required for back titration and neutralization 25 ml of 0.1 N H_2SO4 (for blank); d = normality of NaOH used for titration; 6.25 = conversion factor of N to protein while 14 = atomic weight of N.

3.5.3.2. Determination of fat content

During the estimation of fat content, the ground sample was used from which the fat was extracted with a non-polar solvent, ethyl ether. After extraction, the solvent was evaporated and the extracted materials was weighed.

Fat (%) = (weight of extract/weight of sample) x 100………………………………Equation 10

3.5.3.3. Determination of Ash content

Ash is the organic residue remaining after the water and organic matter have been removed by heating in the presence of oxidizing agents, which provides a measure of the total amount of minerals within a food. The dry ash method was used in this experiment. The ash crucibles were removed from the oven and placed in the desiccators to cool them before weighing them. A sample weight was taken and put into the porcelain crucible. This was then put into the muffle furnace at 600 C. After 2 hours, the crucibles were taken out from the furnace and put into the desiccator to allow cooling. The weight was then taken to determine the ash content

Percentage (%) of ash = (weight of ash/weight of sample) × 100 ……………….…Equation 11

3.5.3.4. Determination of moisture content

Moisture content was determined using the Association of Official Analytical Chemists as outlined by Katola & Kapute (2017).

3.5.3.5. Determination of mineral content

Mineral analysis was done on the following minerals elements; Potassium, Iron, and Zinc which was determined by the methods by AOAC (2005). The ground samples were sieved with a 2 mm rubber sieve and 2 g of each of the samples was weighed and subjected to dry ashing in a porcelain crucible in a muffle furnace. The resultant ash was dissolved in 5ml of HNO_3/HCI/H_2O (1:2:3) and heated gently on a hot plate until brown fumes disappear. To the remaining material in each Crucible, 5 ml of deionized water was added and heated. The solution in each crucible was transferred into a 100 ml volumetric flask by filtration through a filter paper. The solution was used for elemental analysis in an Atomic Absorption Spectrophotometer.

One-way Analysis of Variance (ANOVA) was performed to compare the means of the treatments. Duncan's multiple range test was performed to separate significantly different means between treatments using Statistical Package for Social Scientists (SPSS) version 27.0.

CHAPTER 4: RESULTS

4.1. Mapping of *Synodontis njassae* value chain actors

4.1.1. Demographic characteristics

In this study, education, age, ethnic groups, religion, and number of years stayed in the area were the demographic characteristics considered in the survey. The demographic characteristics of the value chain actors are presented in Table 1.

Table 1 Demographic characteristics of *Synodontis njassae* value chain actors (n=384*)*

Characteristics	**Percentage (%)**
Education	
None	5
Primary	68
Secondary	27
Marital status	
Married	74
Single	19
Divorced	4
Widow	3
Age	
Youth (<=35 years)	63
Adult (>35 years)	37
Gender	
Female	42
Male	58

The value chain was predominantly male-dominated, 58%. The majority of the respondents were youth with a minimum age of 18 years, where 95% of the total sample were literate. The actors are experienced, with an average of 16 yearsof staying in the area.

4.1.2. Actors of *Synodontis njassae* value chain

The main actors of the value chain are shown in Figure 7 below. These are fishers, middlemen, processors, retailers and consumers.

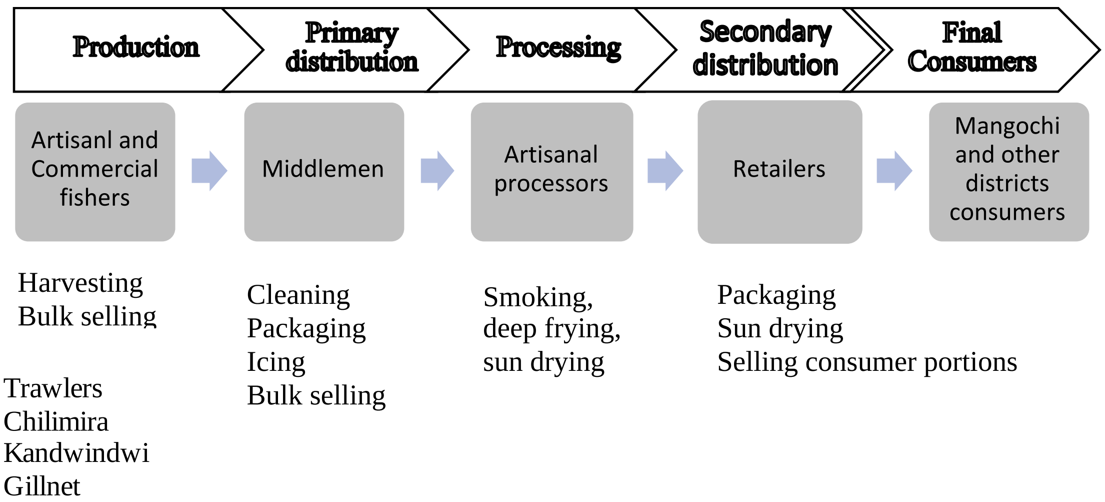

Figure 7 Value chain map of *Synodontis njassae*

4.1.2.1. Fishers

The main activity conducted at this node is the harvesting of *S. njassae* with the help of multiple fishing technologies such as chilimira nets, chambo seine, gillnets, and trawling equipment. Furthermore, supporting activities include making and mending fishing equipment (which requires needles, mesh gauges, and twine), maintaining boats; preparing for fishing, and processing fish after capture. The marketing manner of fishers is individual based.

4.1.2.2. Middlemen

The middlemen node primarily handle the fish in fresh form, with their main activities comprising cleaning, storage, and marketing operations. They distribute the fish through multiple channels, selling directly to retailers in bulk or consumers. The fish is sold either processed or fresh.

4.1.2.3. Processors

The processors employ three primary processing methods: smoking using traditional smoking kilns, deep frying with edible oil, and sun drying. These processors partially sun-dry the fish before processing.

4.1.2.4. Retailers

Retailers source fthe ish from both fishers and middlemen, then transport, package, store, and market the product across various markets within Mangochi District and beyond. Retailers sell the fish in multiple forms, including smoked, fresh, sun-dried, and fried products.

4.1.3. Challenges faced by actors in the *Synodontis njassae* value chain

Figure 8 below shows common challenges experienced by the actors in the value chain of *S. njassae.*

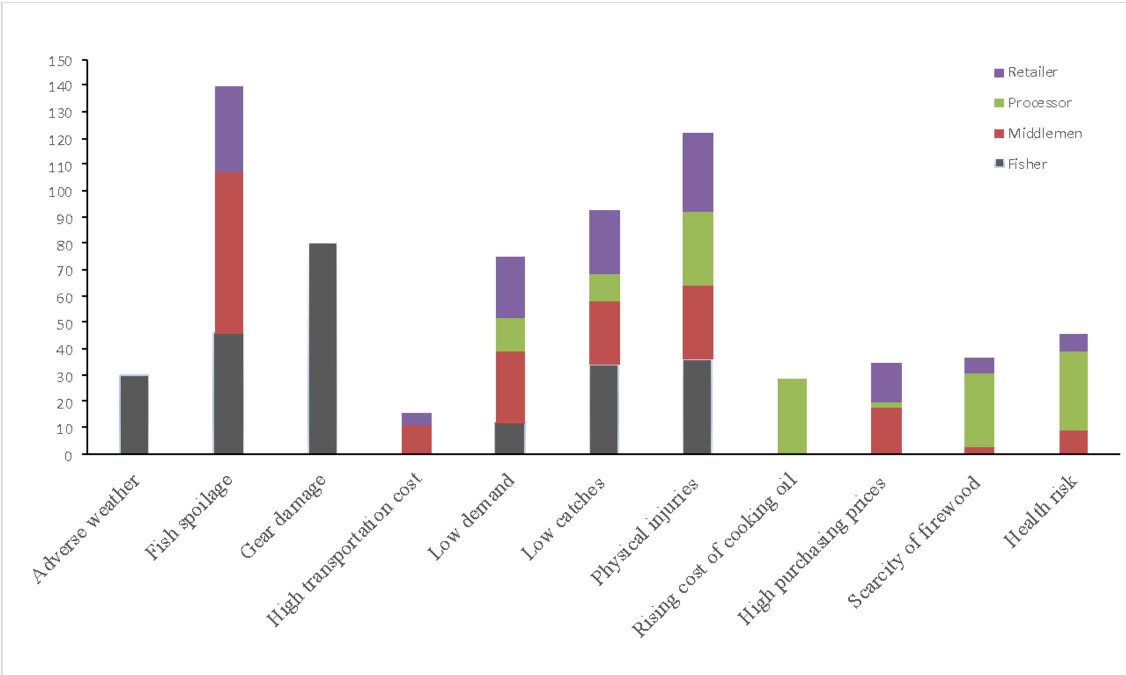

Figure 8: Challenges faced by actors in the *Synodontis njassae* value chain

4.1.3.1. Fishers

Fishers, as primary harvesters, face challenges that affect their routine fishing operations. adverse weather conditions pose a risk to fishers, often resulting in loss of life and fishing gear. The bony spines on the fish cause recurring injuries to the fishers during catching and handling. The lack of onboard cooling facilities causes fish spoilage, particularly during prolonged fishing trips.

4.1.3.2. Middlemen

Middlemen face significant operational challenges throughout the value chain. Economic pressures include high transport costs to reach markets and elevated purchasing prices that squeeze profit margins. Additionally, they encounter low market demand, product spoilage during handling and storage caused by a lack of proper storage facilities, and physical injuries from the fish's bony spines during processing.

4.1.3.3. Processors

Processors face several operational challenges, including firewood heat burns from processing equipment, scarcity of firewood, and injuries sustained while handling the fish.

4.1.3.4. Retailers

Retailers encounter several challenges throughout the value chain; injuries from the fish's bony spines during handling, high transportation costs to reach markets outside Mangochi District, low prices negotiated by consumers that reduce profit margins, and inadequate storage facilities that compromise product quality.

4.2. Market efficiency of *Synodontis njassae*

Table 2 indicates that marketing activities among the actors were efficient since the market efficiency value exceeds 100% (119.56%), indicating that an increase in the cost of performing marketing service by 100 percent will give a more than proportionate increase of 19.56 percent in the level of satisfaction derived from a 5 litre bucket of fish sold in the market.

Table 2 Computation of market efficiency of *Synodontis njassae* value chain in Mangochi

Total cost of marketing	**Values (MK)**
Cost of produce	12,488,000.00
Processing	148,000.00
Storage	22,900.00
Transport	109,300.00
Market fees	34,800.00
Marketing cost by the ith trader	**478,550.00**
Total cost of marketing	**13,281,550.00**
Absolute Margin	
Selling price	15,879,000.00
Total cost of marketing	13,281,550.00
Buying price	12,488,000.00
	-9,890,550.00
Producer share	
Price of buying fish	12,488,000.00
Price of selling fish	15,879,000.00
Producer share	0.786447509
Percentage of producer share	78.64
Market efficiency (ME)	
ME	1.20
ME%	119.56

4.3. Nutrient composition of fresh, fried, and smoked *Synodontis njassae*

Table 4 below shows the nutrient composition of fresh and processed fish samples. The nutrients include moisture, crude protein, crude ash, crude fat, zinc, potassium, and iron.

Table 3 Nutrient composition of fresh, fried, and smoked *Synodontis njassae*

Nutrient	**Processing method**		
	Fresh	**Fried**	**Smoked**
Moisture %	77.61 ± 0.31^{a}	3.47 ± 0.10^{c}	4.87 ± 0.22^{b}
Crude Protein %	23.49 ± 0.47^{a}	22.4 ± 0.30^{b}	19.49 ± 0.73^{c}
Crude Ash %	13.25 ± 0.47^{b}	13.79 ± 0.43^{b}	14.96 ± 0.60^{a}
Crude Fat %	13.57 ± 0.42^{a}	14 ± 0.17^{a}	13.04 ± 0.86^{a}
Zinc mg/kg	0.69 ± 0.00^{c}	0.85 ± 0.00^{a}	0.79 ± 0.00^{b}
Potassium g/kg	73.28 ± 1.86^{b}	89.25 ± 2.19^{a}	80.79 ± 1.00^{ab}
Iron mg/kg	3.15 ± 0.00^{b}	3.88 ± 0.01^{a}	3.15 ± 0.01^{b}

Note: Means with different superscripts (a,b,c) in the same row are significantly different ($p<0.05$)

Moisture was significantly higher in fresh samples and lower in fried samples ($p<0.001$). There was a significant decrease in protein among the processing methods, with the highest content in fresh samples and the lowest in smoked samples ($p<0.001$).

Ash was significantly higher in smoked and lower in fresh samples ($p<0.001$). There was a slight variation in fat across the processing methods ($p>0.058$).

Mineral content (zinc, potassium, and iron) was significantly higher in fried samples as compared to both fresh and smoked samples ($p<0.001$).

CHAPTER 5: DISCUSSION

This chapter presents an interpretation of the study results on value chain mapping, market efficiency, and nutrient composition of *S. njassae*. The findings are triangulated with existing literature on both commercial and underutilized fish species. The study reveals that the S. njassae value chain is relatively simple, with only a few actors involved from production to the final consumer. The main actors identified were fishers, middlemen, processors, and retailers. The value chain demonstrated an efficiency rate of 119%, indicating that all marketing and value addition costs were effectively covered by the actors. Regarding nutrient composition, the study established that the species contains moisture, crude protein, crude fat, ash, iron, potassium, and zinc. The levels of these nutrients are influenced by the processing methods applied by actors along the value chain.

5.1. Value chain mapping of *Synodontis njassae*

5.1.1. Demographic characteristics

The study found that the value chain was predominantly male-dominated. The results are in agreement with previous studies, which concluded that men have more influence in the fish value chain compared to women (Manyungwa-Pasani et al., 2017). According to Chiwaula et al. (2012), the fishing value chain is male-dominated because fishing operations require intensive physical labour that is viewed as beyond women's capacity to perform. High fixed costs and limited access to productive resources discourage women from participating in the sector, mainly in the production node (Tsutsu & Singini, 2021). Young women and men within the age bracket of 35 years dominated the value chain. This indicates that young women and men perceive the fisheries sector as a solid source of livelihood for the fishing communities in Mangochi. The increased youth participation might be attributed to the fact that young women and men are introduced to the sector while they are young to help out as bailers, net menders, carry fish buckets and baskets (FISH, 2015). Education is another important demographic characteristic in any fish value chain. Education is very key in terms of developing the capacity of one individual or nation. The present study has demonstrated that 95% of the respondents were literate, i.e., they can read or write. The high literacy levels might be attributed to increased youth participation, whereby most of them participate outside school hours (FISH, 2015).

5.1.2. Actors in the *Synodontis njassae* value chain

5.1.2.1. Fishers

Fishers are the first players in the *S. njassae* value chain under the categories of Chilimira, Trawl, Kandwindwi and Gillnet. The main aim for the fishers is not to specifically catch *S. njassae*, as it is caught as a by-catch during other fishing activities, rather than in larger quantities. The fishers sell their catches to middlemen and retailers in five-litre buckets. Although this represents extra income for fishers along with regular earnings, it does not constitute their primary source of income (Tweddle et al., 2019). At this level, value addition is rarely practiced. When the fish is caught, the large portion is taken by middlemen and retailers, who take the burden of processing and storing.

Fishers were predominantly male-dominated in the value chain. These results concur with Tsutsu & Singini (2021), who found that male fishers dominated *the E. sardella* value chain. Manyungwa-Pasani et al., (2017) also found that men dominated the fishing activities compared to women who dominate trading and processing in the fish value chain. Men dominance in the fishing node may be due to culture, labour intensity, reproductive responsibilities, high fixed assets costs, and limited access to productive resources (Chiwaula et al., 2012;Tsutsu & Singini, 2021). Furthermore, fishing is mainly done during the night with minimal clothing, hence, women may not be comfortable working in that environment (Manyungwa-Pasani et al., 2017). In addition, the present study has established that common fishing technologies identified in the fish's value require a lot of physical labour of which may not be convenient for most women.

5.1.2.2. Middlemen

Middlemen act as wholesalers at the same time, sell the fish directly to consumers in retail markets and at the door of the consumer. Middlemen sell the fish, whether processed or fresh. According to Tsutsu & Singing (2021) middlemen who also act as wholesalers in the *E. sardella* value chain are also involved in the processing of the fish. Middlemen are preferred by fishers because of their relationship in doing business. Fishers consider some retailers as strangers, hence prefer selling the fish to middlemen. This resonates well with Phiri et al. (2015) who found that fisher-middlemen linkage is deep-rooted since they are sometimes related either by blood or having their fishing village proximity to each other.

5.1.2.3. Processors

The processing techniques commonly applied are smoking, deep frying and sun drying. The processed fish may fetch a reasonable high income at the same time prolonging shelf life compared to unprocessed fish (Etchutakang et al., 2023). Unlike the fishing and middlemen nodes that are dominated by men, the node has a large number of women up to 92% of 96 processor respondents. Women have other household responsibilities to attend that leave them with limited time to participate in the fishing activities, hence, they opt for processing node, which gives them flexible time to attend to family responsibilities (Manyungwa-Pasani et al., 2017; Chiwaula et al., 2012).

5.1.2.4. Retailer

Retailers sell both processed and fresh products and are responsible for packaging fish for consumption in regular portions size. Retailers purchase fish directly from fishers or through middle men (e.g., wholesalers). Tsutsu and Singini (2021) found a relatively large proportion of fresh Usipa retailers purchase fish primarily from fishers while generally bypassing the wholesale node. This means there are comparatively fewer retailers purchasing fish through the wholesale node compared to the total number of retailers purchasing fish through another source. The majority of actors (69 of 96) in the retailing node are women, while the two previous nodes (middleman and fisher nodes) were primarily occupied by men. This finding is also supported by Manyungwa-Pasani et al., (2017) illustrating that women occupy the majority of positions in the post-harvest fishing sector.

5.1.3. Challenges faced by actors in the value chain

Generally, fishers experience challenges in the course of fishing, and these are: (1) Adverse weather conditions, (2) net damage resulting in increased cost of maintaining the net, and (3) injuries when handling the fish caused by bony spines that the fish has. The results agree with Phiri, Dzanja & Kakota (2015) who found that fishers face a wide range of challenges during fishing operations, including losing life due to capsizing of boats because of strong winds on the lake. Middlemen face a diverse range of challenges, including spoilage of the fish resulting from a lack of onboard cooling facilities and extended fishing trips, high transportation costs to outlet markets because of skyrocketing fuel costs, low demand, and injuries caused by the hard thorns on the fish. The results agree with HLPE (2014), who found that spoilage and quality downgrading of fish products are more likely in low-income countries due to lack of basic technologies, onboard cooling facilities, scarcity of firewood, and overreliance on traditional processing techniques. Manyungwa-Pasani et al. (2017) observed that value chain actors are burdened with elevated transportation costs arising from long distances to markets, which consequently diminishes their market margins.

Processors also face a range of challenges, including skin burns from prolonged exposure to heat during smoking and deep frying, injuries caused by hard fish spines during handling, theft of processing equipment, vandalism of smoking kilns, scarcity of firewood for both smoking and deep frying, as well as escalating prices of cooking oil. Uyamadu et al. (2023) reported that fish smoking exposes them to a lot of health risks as a result of prolonged exposure to heat during smoking. Retailers experience a diverse of challenges; high transportation to outlet markets due to increased prices of vehicle fuel, spoilage of the fish caused by poor handling techniques as well as cooling facilities among fishers, lack of proper storage facilities at the beach and outlet prompting retailers to store the fish home, low demand because the species is not frequently found on the market hence consumers focus on popular species, and injuries when handling cause by hard spines on the fish. The results concur with Manyungwa-Pasani et al. (2017); Tsutsu & Singini (2021) who reported that *E. sardella* retailers are challenged in terms of high transportation costs, lack of access to storage and selling facilities for fresh fish at the market. According to Guillen et al. (2014) low demand for less valued fish species is attributed to low landing volumes and high grading for targeted species.

5.2. Market efficiency of *Synodontis njassae* value chain

Market efficiency is a measure of performance comparing net marketing cost to net price as a percentage (Adedeji et al., 2019). When this ratio equals 100%, or 1.0, the market has achieved its potential and is at the break-even point; hence marketing cost equals selling price (Phiri et al., 2013). If efficiencies are less than 1.0, this indicates that participants in the market segment are spending more on value-addition than they make in overhead (Adedeji et al., 2019). The present study has shown that the market efficiency for *S. njassae* value chain is greater than 100% meaning that participants in the value chain are able to pay both the value-addition and marketing costs and generate a profit of 19%. This further means that any upward adjustment of cost of performing marketing service by 100 percent will result into a substantial increase of 19 percent of satisfaction coming from a backet sold. Product nature, and methods of distribution also affect the efficiency of the fish value chain. For example, species with little or no market value receive low prices and have limited marginals. On the other hand, length and number of intermediaries have significant impact on the efficiency of a marketing chain.

In the study conducted by Phiri et al. (2013) it was determined that the inefficiency of the value chain for the Chambo fishery resulted from a large proportion of operating expenses for wholesalers and retailers and, thus, reducing these operating costs would increase the efficiency of the flow of this product through the market channel. The way value chain actors manage their marketing supply chain will affect their bottom line the profitability and sustainability of them because of the way that this management dictates the pricing at which produced goods are sold to consumers. Middlemen and retailers are left with limited options to keep their product longer because of limited access to improved cold storage and processing technologies. There are many technological improvements that can improve efficiencies in a supply chain, such as better transportation methods, temperature-controlled storage, and routing techniques that reduce product spoilage while improving delivery timeliness.

5.3. Nutrient composition of *Synodontis njassae*

5.3.1. Moisture content

The findings demonstrate that processing methods have a significant effect on the nutrient composition. Moisture content was higher in fresh samples compared to smoked and fried fish samples. These results agree with Msuku & Kapute (2018) who also recorded higher moisture content in fresh fish, 72.9% as compared to smoked fish, 12.22%. Katola & Kapute (2017) also reported that smoked *O.mossambicus* retained 24.54% moisture content compared to fresh fish, 91.97%. The results agree with Abraha et al. (2018) that the flesh of fish is comprised of 70-80% moisture. Lower moisture content in fried and smoked fish was due to dehydration resulting from cooking and smoking temperatures. Low moisture content in fried and smoked fish creates unfavourable conditions for the growth of microbial organisms, hence, a prolonged shelf life (Katola & Kapute, 2017; Msuku & Kapute, 2018;).

5.3.2. Protein content

The findings reveal that protein was lowest in smoked fish. This might be attributed to high chemical reactions during smoking because of uncontrolled time, temperature, and type of wood used. Belitz et al. (2009) reported that traditional smoking methods significantly denature protein and amino acids due to overheating. The results are also in agreement with Msuku & Kapute (2018), who recorded decreased content of protein in smoked fish (55.30%) compared to fresh fish (58.86%). Agbozu (2014) reported that smoke contains compounds that affect nutrients like proteins of the fish product, where compounds such as Benzo (a) pyrene (B[a] P) are one of the substances in smoke vapours which dissolve in the liquid on the surface of the fish and have effects on fish protein among other elements. The traditional smoking technique applied in this study has no smoke regulating mechanism, hence exposing the fish to high amounts of smoke, resulting in increased compounds of Benzo (a) pyrene and resulting in reduced protein content in smoked fish.

5.3.3. Fat content

A slight increase in fat content was revealed in fried fish, although no significant difference was registered. The intensity of heat during frying and smoking did not significantly increase or decrease the fat content in fish. The increased fat content in fried fish may result from oil uptake by the fish muscle as well as low moisture content (Holman & Maalekuu, 2013). Furthermore, an increase in fat content is attributed to the decreased moisture content resulting in the concentration of ash and fat content in the fish (Aberoumand, 2014). Fat content in fish products is easily oxidized by atmospheric oxygen, and high temperatures or prolonged exposure to light (Gokoglu & Yerlikaya, 2015). Increased fat content in fried fish may result in rapid spoilage due to fat oxidation, hence compromising the freshness quality of the fish (Aberoumand, 2014). As such, caution should be observed by the processors to prevent breakdown of fats in storage.

5.3.4. Ash and mineral content

Increased ash content in smoked fish might be attributed to increased concentration of salt in the flesh due to dehydration (Katola & Kapute, 2017). In addition, bony fish e.g. *S. njassae* are characterized by higher ash content (Devi & Sarojnalini, 2012). The findings in the present study are consistent with earlier studies by Msuku & Kapute (2018), who found that dry processing increases ash content concentration in fish products. On the other hand, the high ash content in fish might be attributed to contamination with dirt and sand during transportation and processing (Islam et al. 2013).

Minerals (zinc, potassium, and iron) significantly increased in fried fish compared to smoked and fresh fish. The increase might be attributed to greater loss of moisture during frying. According to Kinyuru et al. (2010) mineral concentration increases in frying cooking as result of oil absorption. The type of cooking oil used during frying has a direct effect on minerals content on food products because some of cooking oils are fortified with essential minerals. Similarly Megido et al. (2018) compared the effect of different processing techniques whereby it was revealed that minerals increased in fried mealworms. Mineral concentration is a good indicator of heavy metal occurrence in fish flesh (Ali et al., 2011). Caution must be practiced when consuming fish products with heavy metal concentrations beyond acceptable limits. In the present study, mineral concentrations were within the acceptable limits, for instance, 3.88±0.01 mg/kg of iron was within the most recommended limit of 5mg/kg (Linus-Chibuezeh et al., 2022).

CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS

6.1. Conclusions

The study has shown that the *S. njassae* value chain in Mangochi involves fishers, middlemen, processors, retailers, and consumers. This means the value chain is not very complex, hence providing opportunities for entry to other players who can strengthen the value chain. For instance, the vale chain can be expanded to accommodate actors who can explore products that can be derived from processing the fish other than consumption. The common challenges actors experience in the value chain include physical injuries caused by hard spines on the fish, spoilage due to lack of onboard cooling facilities and proper storage at the beach, low demand, theft and vandalism of processing infrastructure, and high transportation costs.

In this study, it has been established that the value chain has efficient market channels, i.e., actors covered marketing as well as value addition costs, and made a margin above 100%. This is attributed to low market margins and operation costs from middlemen and retailers.

The study has also found that *S. njassae* contains the essential macro and micronutrients as follows: moisture, protein, fat, ash, and minerals. The study has demonstrated that the nutrient composition of the fish is affected by the processing techniques applied. Crude protein decreased in deep-fried and smoked samples, attributed to uncontrolled cooking temperatures during processing. Generally, fried fish retained most of the nutrients compared to smoked fish, which had higher fat and reduced protein content, which can result in rapid spoilage through fat oxidation.

6.2. Recommendations

The study has established that the *S. njassae* value chain is not complex, which presents opportunities for entry by other players. The Department of Fisheries should make deliberate efforts to encourage participation in different sectors, such as value addition, to strengthen the *S. njassae* value chain. These efforts can include public-private partnerships with private institutions to explore different products (e.g., cosmetics, fish feed, sausage, etc.) that can be produced from this species.

Secondly, the study showed that the channels were efficient. This means that the people involved could pay for marketing and adding value without problems. They kept these costs as low as possible. Therefore, the Government of Malawi, through the Department of Fisheries, should encourage more people to join the business..

The nutrient composition analysis has shown that essential nutrients such as crude protein, fat, ash, and minerals are present at acceptable levels. This study recommends further research to compare the nutrient composition of *S. njassae* with that of commercially valuable fish species.

REFERENCES

Ababouch, L, Nguyen, KAT, Castro de Souza, M & Fernandez-Polanco, J 2023, 'Value chains and market access for aquaculture products', *Journal of the World Aquaculture Society*, 54(2): 527–553.

Aberoumand, A 2014, 'Preliminary studies on nutritive and organoleptic properties in processed fish fillets in Iran', *Food Science and Technology*, 34: 287–291.

Abraha, B, Admassu, H, Mahmud, A, Tsighe, N, Shui, XW & Fang, Y 2018, 'Effect of processing methods on nutritional and physico-chemical composition of fish: A review', *MOJ Food Processing & Technology*, 6(4): 376–382.

Adedeji, T, Osundare, F & Ajiboye, A 2019, 'Profitability and marketing efficiency of smoked fish: Empirical evidence from Ondo State, Nigeria', *Journal of Marketing and Consumer Research*, 58: 1–9.

Affandi, MI & Handayani, S 2020, 'Marketing efficiency of organic rice in Lampung Province', *Journal of Physics: Conference Series*, 1500(1): 012063.

Ahmed, I & Sheikh, ZA 2017, 'Seasonal variation in chemical composition and biological indices of snow trout (*Schizothorax niger*)', *American Journal of Food Technology*, 12(1): 1–13. https://doi.org/10.3923/ajft.2017.1.13

Ahmed, I, Jan, K, Fatma, S & Dawood, MAO 2022, 'Muscle nutrient composition of food fish species and nutritional significance: A review', *Journal of Animal Physiology and Animal Nutrition*, 106(3): 690–719.

Association of Official Analytical Chemists (AOAC) 2005, *Official methods of analysis*, 18th edn, AOAC International, Gaithersburg, MD.

Baihaqi, A, Hamid, AH, Romano, R & Yulianda, A 2014, 'Value chain and value addition analysis of cocoa farmers', *Jurnal Agrisep*, 15(2): 28–35.

Belitz, HD, Grosch, W & Schieberle, P 2009, *Food chemistry*, 4th edn, Springer, Berlin.

Boran, G & Karaçam, H 2011, 'Seasonal changes in nutrient composition of fish species from the Black Sea', *Turkish Journal of Fisheries and Aquatic Sciences*, 11(1): 1–5. https://doi.org/10.4194/trjfas.2011.0101

Bukenya, JO, Hyuh, T, Twinamasiko, J & Molnar, J 2012, 'Economics of fish marketing in Central Uganda', paper presented at the Southern Agricultural Economics Association Annual Meeting, Birmingham, AL.

Chavula, GM, Mwamadi, S, Gondwe, E, Ngochera, M, Halafo, JS, Shechonge, AH & Ngatunga, BP 2023, 'Lake Malawi/Niassa/Nyasa Basin: Status, challenges and research needs', *Journal of Great Lakes Research*, 49(6): 102241.

Chiwaula, L, Jamu, D, Chaweza, R & Nagoli, J 2012, *The structure and margins of the Lake Chilwa fisheries in Malawi: A value chain analysis*, WorldFish, Penang.

Devi, WS & Sarojnalini, C 2012, 'Impact of cooking methods on proximate and mineral composition of *Amblypharyngodon mola*', *International Journal of Advanced Biological Research*, 2(4): 641–645.

Eccles, DH 1992, *Field guide to the freshwater fishes of Tanzania*, FAO, Rome.

Etchutakang, YN, Kewir, FV & Nde, DB 2023, 'Post-harvest fish processing and smoke-drying effects on quality', *Journal of Food Processing and Preservation*, 2023(1): 8763080.

Fafchamps, M, Gabre-Madhin, E & Minten, B 2005, 'Increasing returns and market efficiency in agricultural trade', *Development Economics*, 78: 406–442.

Food and Agriculture Organization (FAO) 2018, *The state of world fisheries and aquaculture 2018*, FAO, Rome.

Food and Agriculture Organization (FAO) 2024, *The state of world fisheries and aquaculture 2024: Blue transformation in action*, FAO, Rome. https://doi.org/10.4060/cd0683en

Government of Malawi 2024, *2023 joint biomass assessment survey in Lake Malawi/Niassa*, Ministry of Natural Resources and Climate Change, Lilongwe.

Government of Malawi 2025a, *2024 annual frame survey for small-scale fisheries*, Ministry of Natural Resources and Climate Change, Lilongwe.

Government of Malawi 2025b, *Annual economic report 2024*, Ministry of Finance and Economic Affairs, Lilongwe.

Guillen, J, Macher, C, Merzéréaud, M, Fifas, S & Guyader, O 2014, 'Effect of discards on maximum sustainable yield estimation', *Marine Policy*, 50:207–214.

Hossain, G & Hossain, M 2019, 'Value chain analysis of shrimp in Bangladesh', *Progressive Agriculture*, 30(1): 65–74.

Kaplinsky, R & Morris, M 2001, *A handbook for value chain research*, IDRC, Ottawa.

Manyungwa-Pasani, C, Hara, M & Chimatiro, S 2017, ‘Women’s participation in fish value chains in Malawi’, *Maritime Studies*, 16(1): 1–17.

Phiri, LY, Dzanja, J, Kakota, T & Hara, M 2013, ‘Value chain analysis of Lake Malawi fish: A case study of *Oreochromis* spp.’, *International Journal of Business and Social Science*, 4(2): 170–181.

Porter, ME 2008, *Competitive advantage: Creating and sustaining superior performance*, Simon & Schuster, New York.

Tran, N, Peart, J, Rodriguez, UPE, Chan, CY, Hoong, Y, Siamudaala, V, Njaya, F & Kafakoma, R 2022, *The future of fish supply–demand in Malawi and its implications for nutrition security*, WorldFish, Penang.

Tsutsu, RB & Singini, W 2021, ‘Value chain analysis of *Engraulicypris sardella* of Lake Malawi’, *Journal of Nutrition and Food Science*, 11(2): 790–796.

Tweddle, D, Konings, A, Kaunda, E, Kazembe, J & Magombo, ZLK 2019, ‘*Synodontis njassae*’, *IUCN Red List of Threatened Species*, e.T60843A155041238. https://doi.org/10.2305/IUCN.UK.2019-3.RLTS.T60843A155041238en

Uyamadu, EA, Sridhar, M, Ana, G, & Morakinyo, O 2023, ‘Occupational Health Hazards and Injuries Among Fish Smokers in the Gambia Fishing Communities’, *Discoveries in Agriculture and Food Sciences*, 11(6): 01-14.

APPENDICES

Appendix 1: Questionnaire

My name is Gladson Chikolera. I am a student at Mzuzu University pursuing a Master of Science in Fisheries and Aquatic Sciences.

As part of the African Center of Excellence on Neglected and Under-utilized Biodiversity Project, I am collaborating with Mzuzu University to research underutilized fish species. Specifically, I am interested in understanding the value chain, market efficiency, and nutrient composition of Synodontis njassae in Mangochi District, Malawi.

To achieve this goal, I am seeking your participation in this present survey. Your input will be invaluable in helping me better comprehend this fish species' current status. Your feedback will also aid in identifying any challenges or opportunities that exist within their value chains.

With your help, I hope to generate insights that will be useful in the development of policies and programs that promote sustainable management of these fish species. Thank you in advance for your participation in this important project.

Your participation in this interview will be confidential and will not be shared publicly. Would you like to participate?

Yes [ ]   No [ ]

Date

Section A. Demographic characteristics

1. What is your name? ________________________________
2. Gender: Male [ ]   Female [ ]
3. Age __________
4. Marital status; Married [ ] Single [ ] Divorced [ ] Widow [ ] Widower [ ]
5. Religion: Muslim [ ] Christian [ ] Buda [ ] Rastafarian [ ]
6. Tribe: Yao [ ] Sena [ ] Chewa [ ] Ngoni [ ] Lomwe [ ]
7. level of education; Primary [ ] Secondary [ ] Tertiary [ ] None [ ]
8. Occupation; Employed [ ] Business [ ] None [ ]
9. How many years have you been in the area?
10. How much money do you realize from fish sells per month?;

Section B. Value chain mapping, market efficiency of Nkholokolo

11. What is your role in the fish value chain?

Questions 12 – 20 If the respondent is a fisher

12. Which fishing gear(s) do you use?

    a. Chilimira
    b. Chambo seine net
    c. Gillnet
    d. Kambuzi sein net
    e. Others, Specify___________________

13. *Do you also catch Synodontis njassae during fishing?*

14. *If yes, what percentage of Synodontis njassae is available in the catch (in pails of five litres)?*

15. *How frequent is Synodontis njassae available in the catch?*

    a. Every trip
    b. Sometimes
    c. Never

16. *Which months of the year do you experience highest availability of Synodontis njassae?*

17. *Which months of the year do you experience least catch of Synodontis njassae?*

18. *How do you sell Synodontis njassae at the landing sites?*

    why using that strategy

19. *How much do you generate from the Synodontis njassae sells per trip?*

20. Who determines the price of *Synodontis njassae* during selling?

Question 21 – 24 if the respondent is a processor

21. What processing techniques do you frequently apply to process *Synodontis njassae*?

Sun drying	
Parboiling	
Frying	
Smoking	

22. How much do you generate (in kwacha) per day from processing *Synodontis njassae*?

23. How many people do you assist in processing of *Synodontis njassae* per day?

24. How much do you incur to process *Synodontis njassae* per day?

Question 25 – 35 if the respondent is the retailer

25. *What quantity (in 5l bucket) of Synodontis njassae do you buy per day?*

26. *Who do you buy Synodontis njassae from?*

27. *What form of Synodontis njassae is sold to Consumers?*

Smoked	
Sun dried	
Fresh	
Fried	

Why this type?

28. What is the average cost of the processing method?

29. How is the fish distributed to reach the consumer?

30. *What is the average purchase price of the Synodontis njassae from middleman or Fishermen?*

31. What is the average cost of transport to the consumer market?

32. Do you pay market fees…………? (If yes) how much?

33. *Where do you store Synodontis njassae?*

34. *What is the average cost of storage of Synodontis njassae?*

35. *How much do you generate from Synodontis njassae sales per day?*

Question 38 – 50 if the respondent is the middleman

36. What is the size of your capital?

37. *What is the quantity of Synodontis njassae bought from the fishers in terms of 5l?*

38. In what form do you sell *S. njassae*?

Smoked	
Sun dried	
Fresh	
Fried	

39. How much do you pay for the processing method?

40. *What is the average purchasing price of the Synodontis njassae?*

41. *How do you transport Synodontis njassae to the Market?*

Foot	
Bicycle	
Car	

42. what is the cost of transportation?

43. What is the average cost of packaging?

44. How do you sell the fish?

Direct Selling	
Fish Auctioning	

45. Who do you sell to?

Retailers	
Consumers	

46. What is the total income generated from *Synodontis njassae* sales per day?

47. Do you pay market fees at the Market?

Yes	
No	

(If yes) How much?

48. Which markets the retailers come from?

49. *What are challenges you face as retailer of Synodontis njassae?*

50. What can be the solution to the challenges

Appendix 2: Key informant interview

My name is Gladson Chikolera, a Master's student at Mzuzu University studying Fisheries and Aquatic Sciences. This research, in collaboration with the African Center of Excellence on Neglected and Under-utilized Biodiversity Project, aims to understand the value chain, market efficiency, and nutrient composition of Synodontis njassae (Nkholokolo) in Mangochi District, Malawi.

Your responses will be kept confidential and used solely for research purposes. Would you be willing to participate in this interview?

Date: ______________

Participant Role

BVC member	
Fisheries Officer	
Gear owner	

Years of Experience: ______________

Key discussions

Supply and Availability of Synodontis njassae

1. Do you collect data on *S. njassae* in your routine data collection activities?

2. What quantities and how frequent do you record *S. njassae* data?

3. What is the average selling price at the production node?

4. Can you illustrate the stages of *S. njassae* value chain?

5. What activities are done at each node?

6. What challenges do the actors face in the value chain?

Appendix 3: Research ethics and regulatory approval and permit protocol

MZUZU UNIVERSITY

DIRECTORATE OF RESEARCH

Mzuzu University
Private Bag 201
Luwinga
Mzuzu 2
MALAWI
TEL: 01 320 722
FAX: 01 320 648

MZUZU UNIVERSITY RESEARCH ETHICS COMMITTEE (MZUNIREC)

Ref No: MZUNIREC/DOR/24/54 **25/10/2024.**

Gladson Chikolera,
Mzuzu University,
P/Bag 201, Luwinga,
Mzuzu 2.

Email: glad04chiko@gmail.com

Dear Gladson,

RESEARCH ETHICS AND REGULATORY APPROVAL AND PERMIT FOR PROTOCOL REF NO. MZUNIREC/DOR/24/54: VALUE CHAIN MAPPING, MARKET EFFICIENCY, AND PROXIMATE COMPOSITION OF Synodontis njassae (Cuvier, 1816) (Pisces: Mochokidae) IN MANGOCHI DISTRICT, MALAWI.

Having satisfied all the relevant ethical and regulatory requirements, I am pleased to inform you that the above referred research protocol has officially been approved. You are now permitted to proceed with its implementation. Should there be any amendments to the approved protocol in the course of implementing it, you shall be required to seek approval of such amendments before implementation of the same.

This approval is valid for one year from the date of issuance of this approval. If the study goes beyond one year, an annual approval for continuation shall be required to be sought from the Mzuzu University Research Ethics Committee (MZUNIREC) in a format that is available at the Secretariat. Once the study is

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finalised, you are required to furnish the Committee with a final report of the study.

The Committee reserves the right to carry out compliance inspection of this approved protocol at any time as may be deemed by it. As such, you are expected to properly maintain all study documents including consent forms.

Wishing you a successful implementation of your study.

Yours Sincerely,

Wanangwa K. Msowoya
MZUNIREC Secretariat
FOR: MZUNIREC CHAIRPERSON

MZUZU UNIVERSITY
RESEARCH ETHICS COMMITTEE
25 OCT 2024
PRIVATE BAG 201, LUWINGA
MZUZU 2

Mzuzu University Research Ethics Committee
Directorate of Research
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Appendix 4: Consent form for photographs and interview

Consent for photographs and interview

Please read this document and sign in order to indicate your consent. Should you have any questions in this context please feel free to ask a Mzuzu University member of Staff in the department of Fisheries and Aquatic Sciences for support.

1. **Who am I?**

Gladson Chikolera is one of Master of Science student under the department of Fisheries and Aquatic Sciences. I am conducting a study on value chain mapping, market efficiency, and nutrient composition of *Synodontis njassae* from Lake Malawi, Mangochi district, Malawi.

2. **Why**

I want to collect information about the people involved in the fish value chain.

3. **What**

I would like to record and document your personal story in writing, and in still pictures. In your story **I will only use information about you which you voluntarily share with us**. Such personal information may include, e.g.:

- general information about yourself like your name, your age, or the area where you live;
- **more sensitive information** about you, such as **information about your health.**

Therefore, I will only record your story based on your explicit consent which I ask you to confirm by signing this form. Not signing this form will have no negative consequences for you. When signing this form, please always tell me if there is any information which, despite having shared it with us, you do not want me to include in your story. In this case, I will not use that information. I

For internal archiving and documentation purposes I will use the following personal information:

- Your name
- Your address
- Date and place of recording your story.

I will not pay you for sharing your story and you will not own the content gathered. However, **you do have rights in relation to the personal information** that you provide that we will always respect

How

I intend to use your story for research purposes nothing else

4. **Your Rights**

I understand that you might change your mind in the future and would like to withdraw your consent to using your information and telling your story. Withdrawing your consent will have no negative consequences for you. If you withdraw your consent, I will not use your story in future communications. I may not be able to withdraw images already published.

Item of Consent	**Yes**	**No**
taking (still) pictures:	☐	☐
Tell her / his story:	☐	☐
Disclosing real name:	☐	☐

Full name of the contributor:

……………………………………………………………………

Location/Date: …………………………………………………

Signature(s): ……………………………………………………