integrity Research Journals

Global Journal of Fisheries Science
Volume 8(3), pages 70-82, July 2026
Article Number: 4B5D6F753
ISSN: 2782-750X
https://doi.org/10.31248/GJFS2026.108
https://integrityresjournals.org/journal/GJFS

Review Article

Production and consumption of fish and fishery products in Uganda: trends, status, and implications for food and nutrition security

Caleb I. Adewale[1,2*] and Uttam Deb[2]

[1]Department of Rural Development and Agribusiness, Faculty of Agriculture and Environment, Gulu University, P.O Box 166, Gulu, Uganda.
[2]Department of Aquaculture and Fisheries, University of Arkansas at Pine Bluff, Pine Bluff, AR 71601, USA.

*Corresponding author. Email: calebadewale02@gmail.com

Received Date: 12 May 2026 | Accepted Date: 25 June 2026 | Published Date: 30 July 2026

ABSTRACT: Fish and fishery products provide a variety of essential vitamins, minerals, and fatty acids in addition to their high-quality protein. Fish is a significant source of animal protein in Uganda, accounting for about 50% of animal protein intake. They also play an important role in enhancing household income and food and nutritional security in Uganda. Uganda has abundant freshwater resources, including the River Nile, Lake Victoria, and extensive wetlands, which could serve as key sources for fish production and consumption. This study examines the trends and status of Uganda's production and consumption of fish and fishery products. Data were obtained from the FAO FishstatJ software database and analyzed using trend lines, area graphs, and bar charts. Fish production has increased steadily over the years, with an annual growth rate of 4.2% between 1990 and 2023. Fish consumption in Uganda has also increased over the years. Per capita fish and fishery product consumption increased from 13.71 kg in 1990 to 15.40 kg in 2023. This study highlights the importance of sustainable fish production and consumption practices for ensuring food and nutritional security in Uganda. However, there are significant disparities in fish consumption across regions and socioeconomic groups. Furthermore, overexploitation of fishery resources and lack of infrastructure negatively affect the efficiency and effectiveness of the fish value chain. These constraints call for policies and interventions that promote sustainable fish production practices and enhance the accessibility and availability of fish and fishery products to all Ugandans.

Keywords: Aquaculture, fishery products, food security, nutrition, trends, Uganda.

INTRODUCTION

Aquaculture is increasingly gaining ground globally as the fastest-growing food-producing sector, especially through the production of fish and fishery products. It is increasingly recognized as a crucial industry for providing sustainable food, driving economic growth, and eradicating poverty in emerging nations (Subasinghe *et al*., 2009; Bhujel, 2024). By 2050, the world's population is expected to exceed 9.7 billion people, making it more difficult than ever to feed everyone enough to be healthy. Hunger, malnutrition, and food insecurity remain significant issues, as noted in the United Nations Sustainable Development Goals (SDGs), notably in sub-Saharan Africa (Hamad and Tayel, 2025). Fish and fishery products serve as a vital source of protein in the human diet for millions of people and play a major role in enhancing household income in developing countries (Hishamunda *et al*., 2014). Freshwater aquaculture plays a major role in the production of fishery products, thereby making essential nutrients available to the populace and contributing to economic growth. 8.29 metric tons (MT) of fish were produced in Africa in 2020, accounting for 3% of global catch fisheries production. 3.21 metric tons were produced from African inland catch fisheries (Thiao and Bunting, 2022). Fish and fishery products are a significant source of high-quality animal protein, complementing plant meals, and are frequently consumed by ordinary people in developing countries. Over 26.6% of the animal protein consumed by more than 3 billion people worldwide comes from fish (Kawarazuka and Béné, 2011).

The 17 Sustainable Development Goals (SDGs) and the 169 targets listed in the United Nations' 2030 development agenda, adopted in 2015, are intended to guide the efforts of regional, national, and international organizations to achieve sustainable development over the ensuing 10 years. SDG 2 specifically strives to combat food insecurity and hunger in all of its manifestations (Stronge *et al*., 2020). Despite great advances in the fight against hunger, malnutrition, and food insecurity, there remain major obstacles to overcome. According to WHO (2019), the number of hungry people has climbed over the previous three years to levels last seen a decade ago. An increased risk of diet-related non-communicable diseases exists because around 1 billion individuals lack access to food and essential nutrients. Obesity, undernutrition, and micronutrient deficiencies, known as the "triple burden" of malnutrition, are currently the main contributors to poor health worldwide (Christian and Dake, 2022). In order to meet SDG 2, recent research calls for reforms in the world's food production systems and the provision of high-quality, nutritious diets (De Schutter *et al*., 2020). More than 3 billion people in poor nations depend on fish for 17% of their animal protein and 7% of their total protein intake. Fish are a rich source of essential vitamins, such as high-quality amino acids, omega-3 fatty acids (eicosapentaenoic and docosahexaenoic), and minerals, including iron, zinc, and vitamins, frequently in highly bioavailable forms. As a result, fish is widely regarded as "nature's superfood." (Kwasek *et al*., 2020).

Globally, fish consumption is rising at a higher rate than the global population. This is due to increased awareness of the benefits of fish consumption, rising urbanization, and rising income among its populace (Wake *et al*., 2019). Aquaculture and fisheries help generate economic returns through the production and marketing of farmed and captured fish and directly provide highly nutritious, protein-rich diets (Ahmad *et al*., 2016; Wake *et al*., 2019). The impressive increase in fish output over the past seven decades, from 19 million metric tons (MT) in 1950 to 122 million metric tons (MT) in 2020, has been attributed in part to fish production methods. (FAO, 2022). The production of fish as food is anticipated to increase in the coming decades due to the fastest rate of growth of the aquaculture sector in the world. According to the OECD-FAO Agriculture Outlook, an increase in aquaculture production would raise world fish production by more than 1% per year over the next ten years, reaching 195 MT by 2027 (Obiero *et al*., 2019).

Currently, fish is the primary source of animal-based protein for over 30% of Africa's population (about 200 million people). Additionally, 12.3 million Africans are employed in the aquaculture sector, of whom 5.3 million (42%) are processors, 6.1 million (50%) are fishermen, and 0.9 million (8%) are fish farmers (Yazew *et al.,* 2020). Like other developing nations, Uganda depends on agriculture, particularly fisheries and aquaculture, to lay the groundwork for expanding and improving its export industry (Munguti *et al*., 2024). Uganda is blessed with immense freshwater natural resources accounting for 18.2% of its land surface area. They include White Nile River, extensive wetlands, and major lakes such as Lake Victoria. Although about 35% of these resources originate from neighboring countries (Kasozi *et al*., 2017). The fishery industry in Uganda contributes significantly to the nation’s foreign revenue earnings and helps to reduce poverty through employment opportunities. USD135 million in foreign exchange is generated by fisheries in Uganda each year (Mbowa *et al*., 2017). Uganda’s fish production is thought to be worth a total of USD24 billion yearly, which is equivalent to 12% of agricultural gross domestic product (GDP) and 3% of the nation’s gross domestic product (Yazew *et al*., 2020). Despite the increasing demand for Ugandan fish products, export growth and potential have been constrained by the overexploitation of fishery resources. Its potential for enhancing contribution to the eradication of poverty, wealth creation, and food security is hampered by several issues that are preventing long-term resource sustainability (Muringai *et al*., 2021).

Studies revealed that 2.6 million people in Uganda are food insecure, meaning they consume fewer than 2,350 Kcal per day, which is the recommended daily calorie intake. Additionally, about 12.3 million individuals (30.1%) earn less than $1.77 per day or less than the poverty level (IPC, 2020; Musoke, 2021). One of the key endeavors supporting Uganda's broad-based sustainability is the capture fisheries. More than 1.2 million people in the region depend directly or indirectly on fisheries and fish-related activities for their daily needs (Namubiru *et al*., 2024). Fish and fishery products can be harnessed to eliminate food and nutrition insecurity in Uganda because they are a crucial component of the country's agri-food system (Chan *et al*., 2019). Fish make up 12% of Ugandans' animal protein diet and play a distinct part in making a variety of essential nutrients and fatty acids (long-chain polyunsaturated fatty acids) that cannot be simply replaced by other food products available to consumers. Moreover, fish is a highly effective converter of feed into high-quality food, thereby making it a very good source of protein for a nutritious diet (Ahern *et al*., 2021).

Despite the high reliance on fish protein in Uganda, there is a gap between the recommended annual consumption and actual consumption levels. The annual average requirement of fish consumption per individual is 17.2kg, but the actual consumption level in Uganda is only about 12.5kg per year (Ssegane *et al*., 2012), although it has increased to about 15kg per year in recent times (FAO FishstatJ, 2025). This implies that most of Uganda's population is not meeting its daily protein requirements, which can lead to malnutrition and other health issues. This problem is compounded by the rapid population growth in Uganda, which is causing an increase in demand for fish protein. With current consumption already below the recommended levels, the demand for fish protein is likely to rise further in the coming years. This study, therefore, examined the trends and status of fish and fishery products and their implications on food and nutrition security.

METHODOLOGY

This study used secondary data from the FishstatJ software and the Food and Agriculture Organization (FAO) database. FishstatJ is a comprehensive fisheries statistics tool developed by the FAO, providing access to global fisheries and aquaculture data collected from national and international sources. The FAO database contains extensive information on fish production, consumption, trade, and other relevant indicators, facilitating the analysis of trends and patterns within the fisheries sector (FAO FishStatJ, 2025). Data were also obtained by reviewing existing literature.

The analytical approach employed in this study involved trend analysis using area and line graphs to examine the historical patterns and trajectories of fish production and consumption in Nigeria via time-series data (1990 to 2023). Bar charts were used to describe the different fish species produced in Uganda.

FISH PRODUCTION, TRENDS, AND HARVEST

The British government first introduced carp into Uganda in 1941, marking the beginning of the nation's aquaculture industry, and the Kajjansi Experimental Station was established in 1953 (FAO, 2019). Initial fish production was primarily carried out in small garden pools for domestic use, with a focus on feeding and nourishing fish with kitchen leftovers. Despite its lengthy history, the industry remained at a subsistence level until the early 2000s and contributed little to the country's fisheries output (FAO, 2022; Eyayu *et al*., 2023). However, there was a significant turning point in the fisheries sector after the introduction of cage culture in Lake Victoria in 2006 (Mbowa *et al*., 2017). One major challenge to the sector's growth at that time was the lack of readily available industrially produced pelleted feed. Efforts by development partners such as the FAO and the government led to a growth in aquaculture output from 15,000 tons to 118,000 tons between 2005 and 2015. After 2018, subsistence farmers and small and medium-sized producers controlled Uganda's aquaculture industry (FAO, 2004-2023). The country supplies feed, fish seeds, fish and fishery products, aquaculture inputs, and technical know-how to its neighboring countries, primarily Rwanda and Kenya.

The inland fishery sector provides a living for nearly 6.1 million Ugandans, making it the seventh-largest in the world (FAO, 2019). In addition to being the main food supply and a means of survival in Uganda, fishing also contributes to important exports and helps boost the local economy. This industry has consistently been a source of employment opportunities for many people. Records show that 1.2 million Ugandans labor primarily in fisheries capture, and another 5000 are engaged in industrial fisheries processing. Even though post-harvest losses in the industry typically range from 10% to 20%, there is a sizable amount of room for improved output (MAAIF, 2017).

Uganda's total fish production has been increasing steadily over the last 10 years, with a compound annual growth rate of 5.05%. In 1990, total production was 245 thousand tons, and it reached 846 thousand tons in 2023, indicating a 245% increase (Figure 1). The captured fishery production constitutes a significant portion of Uganda's total fish production (Adeleke *et al*., 2020). Ugandan captured fisheries increased from 245 thousand tons in 1990 to about 716 thousand tons in 2023, indicating a 192% increase (Figure 1). Uganda is the third-largest aquaculture producer in Africa and ranks second among sub-Saharan African producers, behind Nigeria, with production rising from roughly 52 tons in 1990 to approximately 130 thousand tons in 2023, indicating a marked increase in the volume of freshwater fish farmed (Figure 1). Nile tilapia (*Oreochromis niloticus*) and African catfish (*Clarias gariepinus*) are the two major fish species that are most frequently cultured in Uganda. Nile tilapia accounted for 40% of overall production between 2007 and 2011, with catfish making up 60% (Figure 2). African Catfish production dominated aquaculture production at the time due to hatchery managers' knowledge of breeding technology (FAO 2004-2023). However, Nile tilapia is now more frequently being produced by fish farmers in Uganda due to its delicious appeal and prolificacy. Furthermore, they have become the most popular fish species among consumers in Uganda (Hyuha *et al*., 2017; Akena and Mwesigwa, 2021). 89,683 tons of Nile tilapia were produced in 2023, compared to 39,742 tons of African catfish, accounting for about 69% and 31% of aquaculture production, respectively (Figure 2).

Regarding growth rate and level of fish production by sources of production over the last two decades (1990 – 2023) in Uganda. The level of aquaculture production in Uganda increased substantially, at a compound average rate of 29.80%; the level of captured fisheries in Uganda increased at a compound average rate of 3.64%; and total fish production in Uganda increased at a compound average rate of 4.22%.

Major captured species

The main fish species captured in Uganda include Cyprinids, Silver cyprinid (silverfish), Nurse tetra, Nile

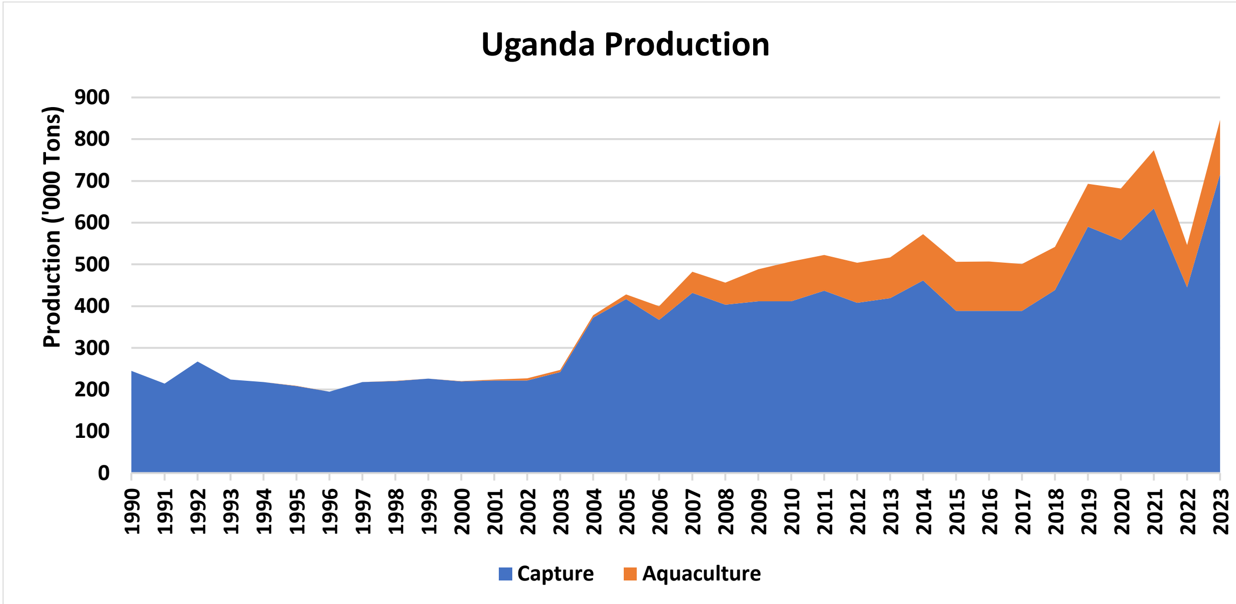

Figure 1. Trends in aquaculture and fisheries production in Uganda: 1990-2023 (**Source:** Prepared by Authors, based on FAO FishStatJ data).

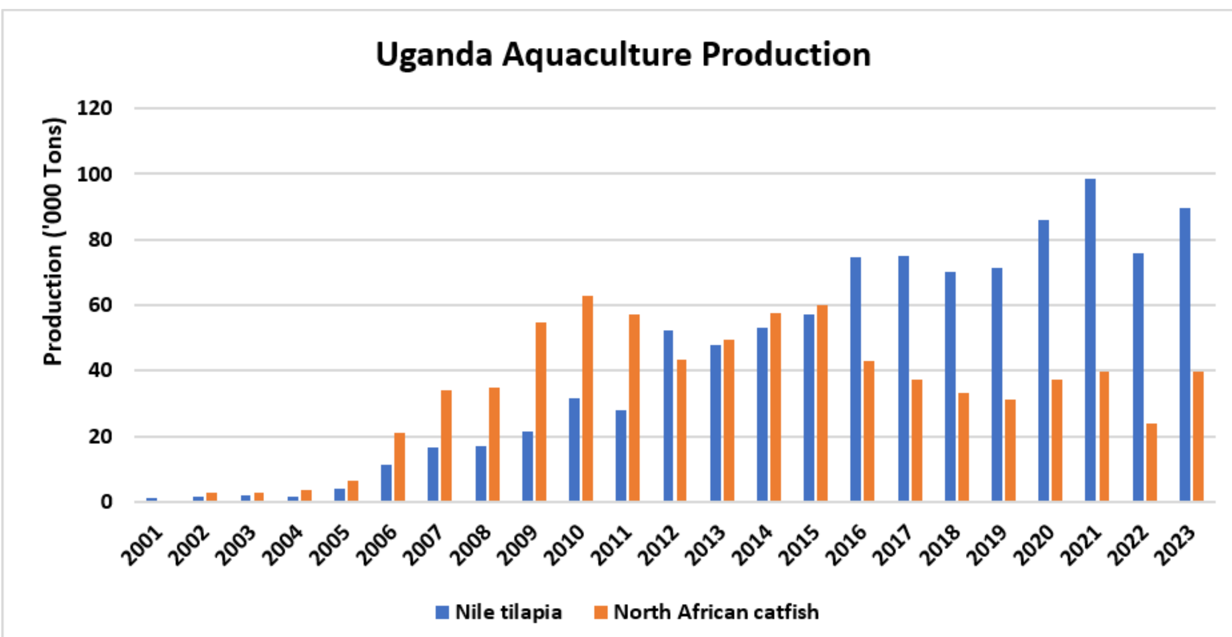

Figure 2. Aquaculture production by species in Uganda: 2001-2023 (**Source:** Prepared by Authors, based on FAO FishStatJ data).

perch, Tilapias, Characins, Torpedo-shaped catfishes, African lungfishes, and Freshwater fishes (FAO, 2022). Others are Naked catfishes, Upsidedown catfishes, Barbel, and Elephant snout fishes. The trends of captured fisheries (Figure 3) show that Cyprinids, Silver cyprinid, Nurse tetra, Nile perch, and Tilapia are the top 5 most captured fish species in Uganda, accounting for 129,629 tons, 152,427 tons, 108,894 tons, 87,808 tons, and 93,803 tons, respectively, in 2023.

Fish consumption trends

According to the United Nations (UN), the average amount

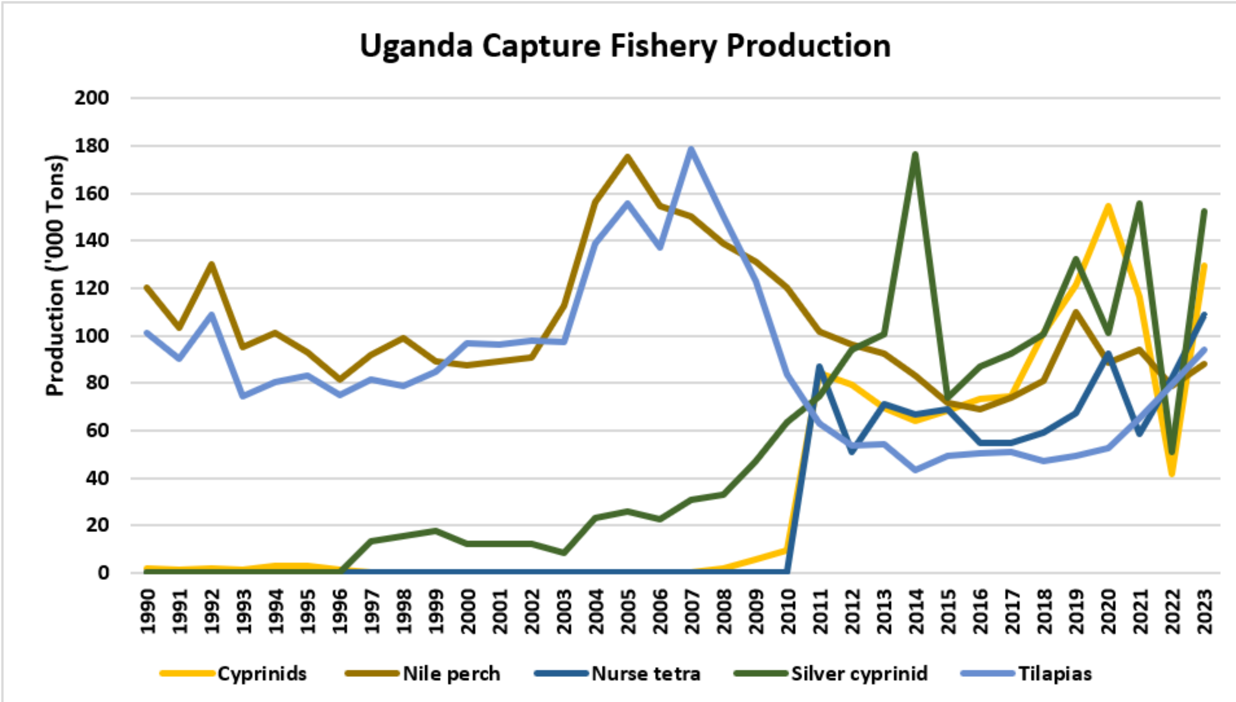

Figure 3. Trends in capture fisheries production by species in Uganda: 1990-2023 (**Source:** Prepared by Authors, based on FAO FishStatJ data).

of fish consumed globally per person has increased from about 9 kg per year to about 20.5 kg per year (Obiero *et al*., 2019). Even though fish account for over 30% of Africa's total animal protein, the continent's per capita fish intake is almost half the world's average. Projections for per capita fish consumption show that, with the exception of Africa, fish consumption is anticipated to rise globally as population growth outpaces fish availability. Fish intake in Africa is predicted to reduce by 3% from 9.9 kg in 2015–2017 to 9.6 kg in 2027, with SSA experiencing a more significant decline (Muringai *et al*., 2021).

Fish and fishery products are an important source of animal-based protein, representing approximately 50% of total animal protein consumed in Uganda. Diverse vital minerals, vitamins, and fatty acids are available to fish consumers, and this makes fish and fishery products an important component of a healthy and balanced diet. Population growth, economic wealth, urbanization, and changing dietary patterns in Uganda have all contributed to a sharp rise in the demand for fish (Tacon and Metian, 2013). According to the Uganda Bureau of Statistics (UBOS) and FAO data, per capita fish and fishery product consumption in Uganda has increased from 13.71 kg in 1990 to 15.40 kg in 2023, representing over 50% of the total animal-based protein intake (Figure 4). Further, the growth rate and level of average per capita annual fish consumption show that per capita annual fish consumption increased by 0.34% in Uganda over the last two decades (1990 – 2023). This increase is attributed to the growth in fish production, which has made fish and fishery products more affordable and accessible to consumers (UBOS 2020). In addition, the growth of urban centers in Uganda has created a market for fish and fishery products, leading to an increase in demand for these products. However, there are significant disparities in fish consumption across regions and socioeconomic groups in Uganda, which may be attributable to geographic, cultural, and ethnic variation. For instance, Fish cultivation is prohibited in communities that raise livestock in Uganda because it is thought that fish reduce milk output (Kasozi *et al*., 2017).

Fish consumption is higher in urban areas than in rural areas, with urban residents consuming an average of 19.6 kg of fish per capita compared to 10.8 kg per capita for rural residents in 2017. Furthermore, high-income households consumed more fish than low-income households, with the former averaging 20.3 kg per capita compared to 12.1 kg per capita for the latter (Mottaleb *et al*., 2021). The disparities in fish consumption are attributed to several factors, including differences in the availability, accessibility, and affordability of fish and fishery products (Atukunda and Ahmed, 2019). In rural communities where most people reside, fish is less accessible due to limited infrastructure and market access, while in urban areas, the price of fish may be too high for low-income households to afford (Kasozi *et al*., 2017).

To promote increased utilization of fish and fishery products in Uganda, it is essential to address these disparities through policies and interventions that enhance

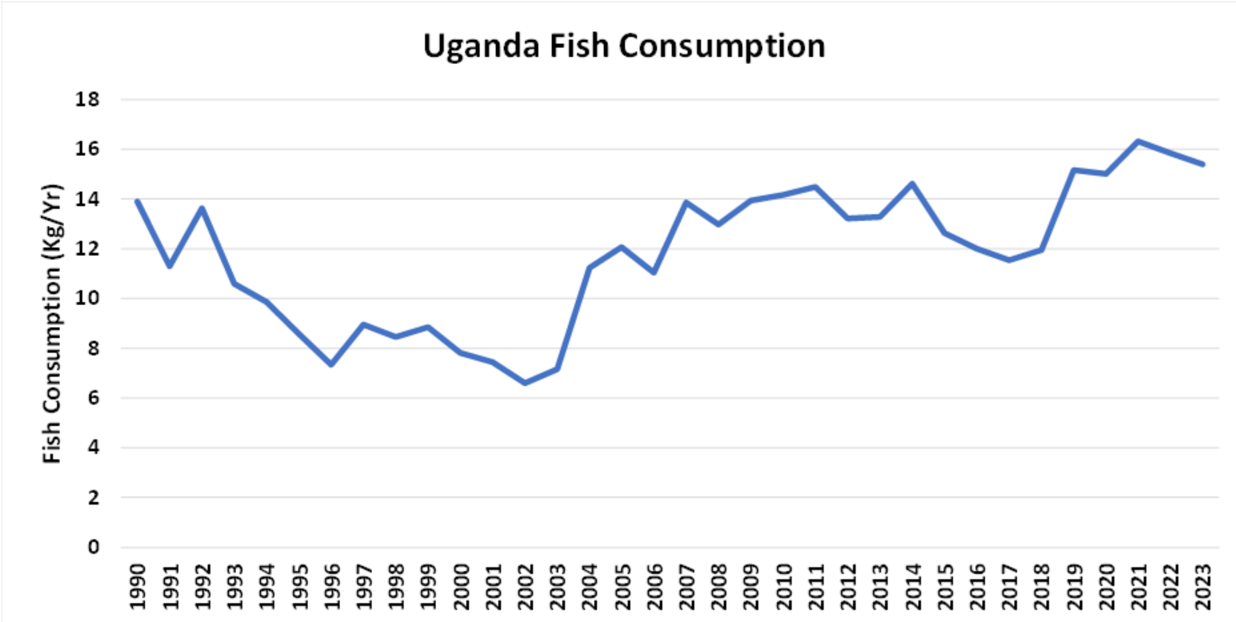

Figure 4. Per capita fish consumption (kg/ yr) in Uganda: 1990-2023 (**Source:** Prepared by Authors, based on FAO FishStatJ data).

access, affordability, and availability. Such interventions could include promoting sustainable fish production practices, improving infrastructure, and implementing policies that enhance the purchasing power of low-income households. These interventions could help improve food and nutrition security in Uganda while enhancing the fishery sector's contribution to the country's economy.

THE ROLE OF FISH AND FISHERY PRODUCTS IN ENSURING FOOD AND NUTRITION SECURITY

Despite fish and fishery products having a key influence on food security, livelihoods, and nutrition, the fisheries industry has long been excluded from important food policy discussions and the financing that accompanies them. For instance, to meet the objectives of SDG 2 (zero hunger), the UN primarily focuses on agricultural systems, such as livestock and plant gene banks, resilient agrarian practices, agricultural subsidies, access to land, and soil quality; there has been no specific mention of the fisheries sector, nor has there been any specific guidance pertinent to the fish value chain (Hambrey, 2017). However, empirical evidence reveals that fishery industries can help to drastically decrease starvation and malnourishment, especially in Uganda (Muringai *et al*., 2021). Fish should be included in dietary and nutritional plans and generally accepted as a diet rather than an element of natural resources. Fish is an important micronutrient and a rich source of animal protein; development agencies and policymakers ought to incorporate fish in policies to enhance overall food and nutrition security in Uganda (Obiero *et al*., 2019; Hasselberg *et al*., 2020).

The fisheries sector continues to be a significant source of livelihood for hundreds of millions of people worldwide. The global development plan strongly emphasized poverty reduction and food security, but these two issues have changed due to population growth, shifts in the global economy, technology, and environmental conditions (Rivera and Qamar, 2003). Food and nutrition security is a vital indicator and driver of overall economic and social welfare, defined as dependable access to food of sufficient quality and quantity to lead a healthy and active life and to enjoy sufficient health services and a sanitary environment. According to this definition, the four main aspects of food and nutrition security are utilization, access, stability, and availability (Shetty, 2015; Simelane and Worth, 2020). Conversely, food insecurity is described as the inability to individually obtain palatable foods that meet societal requirements in a manner acceptable to society, or as an uncertain or limited supply of foods that are nutritionally sufficient and secure (Nettle *et al*., 2017). Food insecurity affects the health and nutritional status of household members by limiting the availability and quality of their diets. Studies conducted in both developing and developed nations found conflicting results regarding the impact of household food insecurity on children's nutritional state (Mulu and Mengistie, 2017). As a result, fisheries play significant roles in supplying income and food in several emerging nations, either as independent endeavors or in conjunction with crop cultivation and livestock production (Smith *et al*., 2005).

The fisheries industry plays a crucial role in increasing the intake of animal-based proteins and attaining food security for the expanding population. The economic output from this sector significantly reduces poverty and promotes food security through three key, interconnected pathways: income for those working in the industry, spillover and multiplier effects in regions dependent on fisheries, such as revenue generation from taxation, exportations, and payment for access to resources in aquaculture by foreign investment, and lastly, nutritional benefits from fish consumption (Boto *et al*., 2013). Small-scale fishing and associated activities are a major source of revenue for rural communities in many areas of Africa, where few or no other job options exist. Various activities in the fish value chain offer people an essential and occasionally vital safety net that shields them from the impacts of fluctuating agricultural product prices, structural reforms, macroeconomic crises, failed harvests, political unrest, and other factors that jeopardize food security and rural stability (Béné and Heck, 2005).

Composition of fish nutrients

The number of nutrients in fish depends on the species and its aquatic habitat in terms of harvest waters, thus leading to varying nutrient content among fish species (Youn *et al*., 2014). Data on the specific dietary makeup of different species are scarce, especially for those eaten in Uganda. However, fish is an abundant source of protein and important minerals. Its health-promoting and nutritional characteristics are increasingly being recognized (Benjakul *et al*., 2014). Typically, fish muscles make up 50–60% of the total weight of the fish and contain 16–21% of the protein. Proteins in fish are categorized mainly into the stroma, sarcoplasmic, and myofibrillar, which together make up 70–80%, 20–30%, and 3% of all proteins in fish muscles, respectively (Ghaly *et al*., 2013).

The consumption of 100 g of fish can provide between 15–25% of the overall daily protein needs for adults who consume the recommended 45–65 g of protein per day. Additionally, fish protein has a higher bioavailability than plant protein, by 5–15% (Egerton *et al*., 2020). Eicosapentaenoic acid (EPA), Arachidonic acid (ARA), and docosahexaenoic acid (DHA) are three long-chain unsaturated fatty acids (LCPUFA) found in fish. Anchovies, mackerel, sardines, and some salmon species are among the fish species high in DHA and EPA, making them significant sources of these fatty acids (Pike and Jackson, 2010; Gladyshev and Sushchik, 2019). However, based on their aquatic habitat, spawning period, physicochemical processes, and species feeding patterns, there may be varying amounts of total lipids among fish species and across different tissue organs (Rasul *et al*., 2021). Additionally, fish is a significant source of bioavailable micronutrients such as iodine, zinc, selenium, iron, calcium, phosphate, and fluorine, as well as essential micronutrients such as vitamins A, B, and D (Maulu *et al*., 2021). The Food Composition Database for Fish and Shellfish (uFiSh) contains nutrient data for a variety of fish species, spanning diverse capture areas and/or aquaculture production sources. However, only 25.7% of the 2033 species mentioned in the database have their nutritional constituents displayed (FAO, 2011).

Benefits to human health and nutrition

For many impoverished or rural communities, the most readily available and affordable form of animal-based protein could be fish and fishery products. Researchers agree that consuming fish contributes to improved maternal and child health, strengthens the immune system, supports the development of the intellect, reduces stunted growth in children, lowers the risk of cardiovascular disease, prevents cancer, lowers the levels of cholesterol and blood pressure, and decreases inflammatory illnesses such as arthritis (Maulu *et al*., 2021; Muringai *et al*., 2021). According to the FAO and World Health Organization, eating fish, especially fatty fish that contains both EPA and DHA, reduces the chance of dying from coronary heart disease by up to 36% (Greene *et al*., 2013). The consumption of fish and fishery products is crucial for women of reproductive age, expectant women, and breastfeeding mothers because it supports fetal and newborn neurodevelopment. Polyunsaturated fatty acids in the form of DHA in fish favorably influence and promote the optimum brain and neural system development in newborns and children, which is crucial during pregnancy and the first two years of life (Aumeistere *et al*., 2018). Similarly, fish enhances the uptake of micronutrients such as zinc and iron from plant-based meals when both fish and plant-based meals are eaten together (Kawarazuka and Béné, 2010).

The role of fish and fishery products in contributing to food and nutrition security and human health has been seen in some countries in sub-Saharan Africa, as reported in the literature (Fiorella *et al*., 2018; Marinda *et al*., 2018; Akuffo and Quagrainie, 2019). This strongly suggests that the prevention of some severe diseases, including diet-related diseases, in the contemporary world may be made possible by consuming fish and fishery products, particularly in Uganda, where there are severe nutrient deficiencies.

Hazards to human health

Consuming contaminated fish poses health risks despite being a goldmine of crucial minerals beneficial for human health. Several dangerous substances (organic and inorganic), which are harmful to human health, can be found in fish. Heavy metals like methylmercury, organic tin, and cadmium are among the substances discovered in polluted fish that offer the greatest health risks (Kimáková *et al*., 2018). For instance, methylmercury, a neurotoxin, is known to have the highest harm to people and has been linked to affecting the peripheral nervous system in adults, leading to ataxia, atrophy, and loss of hearing and speech, as well as affecting the central nervous system in children (Grandjean *et al*., 2010). Furthermore, methylmercury exposure during the development of the fetus has been linked to birth abnormalities, severe mental retardation, and even fetal mortality (Mahaffey *et al*., 2011).

The majority of inland waterways contain cyanobacteria, which produce dangerous cyanotoxins, highly toxic secondary metabolites. Cylindrospermopsins, nodularins, and microcystins are just a few of the poisons that build up in fish tissues (Aklakur *et al*., 2023; Amoda *et al*., 2025). Eating contaminated fish can lead to skin toxicity, gastric disorders, liver damage, and renal impairment in humans. In addition, a significant rise in the use of antibiotics and other antimicrobial agents, including those used in human therapeutics, has slowed the growth of the aquaculture subsector. This is because these drugs are being used to overcome problems related to unhygienic and unsanitary conditions in aquaculture (Pandey and Madhuri, 2014). According to several studies, unrestricted antibiotic use is harmful to fish and human health (Samanidou and Evaggelopoulou, 2007; Rasul and Majumdar, 2017; Okocha *et al*., 2018). Despite the health risks connected to eating contaminated fish, experts generally concur that the benefits of consuming an abundance of fish outweigh any possible drawbacks related to contamination risks (Hosomi *et al*., 2012; Gil and Gil, 2015; Vianna *et al*., 2020).

Enablers and constraints

Fish production and consumption in Uganda are influenced by a range of enablers and constraints that affect the accessibility, availability, and affordability of fish and fishery products. Understanding these enablers and constraints is crucial for developing policies and interventions that promote sustainable fish production and consumption practices in the country (MAAIF, 2017).

ENABLERS OF FISH PRODUCTION AND CONSUMPTION

Abundant freshwater resources

Uganda is characterized by numerous freshwater resources, such as the River Nile, Lake Victoria, and wetlands, which are key to fish production and consumption in the country. The abundance of freshwater resources in Uganda creates a conducive environment for fish farming and fishing, which can contribute significantly to poverty reduction and food security in the country. Rivers and streams in freshwater ecosystems naturally transport nutrients and salts from the mountains to the lower elevations, such as lakes, ponds, and wetlands. These nutrients support the growth of phytoplankton, which is a primary food source for fish. Additionally, the waterways provide a migratory route for fish, such as salmon, to move between different habitats, which helps sustain fish populations (National Geographic, 1993-2003). In Uganda, fish farming and fishing are primarily practiced in freshwater ecosystems, where fish species are abundant, including Nile tilapia, Nile perch, and catfish. Abundant freshwater resources support fish production and consumption by providing suitable environments for fish farming and wild fish catch. The country's rivers, lakes, and wetlands serve as important habitats for fish, providing nutrient-rich environments for growth and migration. However, the sustainable management of freshwater resources is critical in ensuring the continued growth of the fish industry in Uganda (Balirwa and Kamanyi, 2005).

Supportive policies

Supportive policies play a critical role in enabling fish production and consumption. The Ugandan government has implemented regulations and policies that promote the development of the fisheries sector, including the establishment of the Fisheries and Aquaculture Research and Development Institute and the National Fisheries Resources Research Institute. One such policy is the National Fisheries and Aquaculture Policy (NFAP), which seeks to promote sustainable fish production and consumption, as well as the development of the fishery industry (MAAIF, 2017). The policy identifies various challenges facing the sector and proposes several interventions, including building the capacity of fish farmers through training and extension services, providing infrastructure, such as landing sites, cold storage facilities, and fish markets to support fish production and trade, and promoting research and development in the sector, including the introduction of new fish species and technologies for fish production and processing (FAO, 2022b). In addition to the NFAP, other programs and policies have been implemented to support the production and consumption of fish in Uganda. For instance, the Agriculture Sector Development Strategy and Investment Plan (DSIP) 2010/11-2014/15 identifies fisheries as a priority sub-sector and outlines interventions to improve its productivity and profitability. The DSIP interventions include promoting research and development, developing the value chain, improving market access, and strengthening governance and regulation in the sector (MAAIF, 2010).

Availability of labor

Labor is always accessible in both urban and rural areas. However, the cost varies depending on location. It is generally believed that human resources are relatively cheap across developing nations, particularly in Uganda. In general, culture and capture fisheries in Uganda can, directly and indirectly, employ a substantial number of individuals, decreasing the unemployment rate in urban and rural areas and providing for their needs. Although the accessibility of manpower and improved output alone may not ensure sustainable production in the sector, the number of laborers involved in capturing fish should be maximized in every catching site to guarantee sustainable fisheries production and harvest (Eyayu *et al*., 2023).

Growing demand and consumption of fish

The growing demand for fish and fishery products, both domestically and internationally, has created opportunities for fish producers and traders, thus contributing to the growth of the fisheries sector. The average global per-capita apparent fish consumption increased in the 1960s from 9.9 kg to 17.0 kg in the 2000s. In 2018, consumption increased to 18,9kg, and it has been predicted to increase to 21.2 kg in 2024 (FAO, 2019). Factors such as population expansion, increasing wealth, and urbanization have been the driving force behind this extraordinary rise, all of which have been linked to huge increases in fish output and contemporary delivery networks. Increased demand for fish products raises prices and boosts fish farmers' earnings. This encourages additional farmers to enter the industry, creating jobs for marginalized groups. In such cases, relevant stakeholders ought to encourage striking a balance between the consumption rate and the quantity of stock in store (Eyayu *et al*., 2023).

Growing population and urbanization

According to the Food and Agriculture Organization (FAO), the fisheries industry in Africa employs 12.3 million people as full-time fishermen or full-time and part-time processors, constituting 2.1% of Africa's population aged 15 to 64. Women account for approximately 27.3% of those working in African fisheries and aquaculture, with considerable differences in their numbers among processors (58%), aquaculture employees (4%), and in inland and marine capture fisheries (23% and 16%, respectively) (FAO, 2020). Aquaculture can provide sustainable economic growth, support resilient working waterfronts and coastal communities, drive employment in other areas of industry such as fish feed production and fish processing, and create year-round jobs (NOAA Fisheries, 2020). It is believed that rising incomes and increased urbanization will lead to changes in fish consumption patterns. The importance of aquaculture and sustainable fisheries management in feeding a growing global population highlights the potential for growth in the fisheries industry. Additionally, the potential for increased fish consumption due to rising incomes and urbanization may provide opportunities for growth in the industry (Wake *et al*., 2019).

CONSTRAINTS FACING FISH PRODUCTION AND CONSUMPTION

Lack of quality feed

Quality feed remains one of the major constraints to increasing output in aquaculture, especially at the small and medium-scale levels (Eyayu *et al*., 2023). For aquaculture to compete with capture fisheries, low-cost, high-quality feed must be provided and sustained. Additionally, Uganda's actual and projected rapid population growth will drive the region's expanding demand for fish feed. The anticipated growth in fish food consumption implies significant prospects for entrepreneurs in the fish sector to contribute to the development of the nation's economy (Ragasa *et al*., 2022).

Overexploitation and declining yields

Overutilization of fishery resources endangers ecosystems and the financial stability of fishing communities, notably their food security. Overfishing and unregulated fishing techniques negatively affect the quality and quantity of available captured fish, thus frequently contributing to food insecurity and poverty (Canty and Deichmann, 2022). Decreasing fish output has serious consequences for nutrition and food security, job opportunities, and standards of living for households involved in fishing and for the many people who rely on fish as their primary or exclusive source of animal-based protein. The actual cost of dwindling fish supplies is borne by the most vulnerable and impoverished individuals, thus leading to inadequate access to fishery products, which are a critical source of nutrients such as minerals and protein (Muringai *et al*., 2021). Moreover, diminishing fish harvests decrease household income, limiting people's access to economically nutritious and safe food of their choice. It is commonly accepted that aquaculture will meet the anticipated rise in demand for fish through greater food production. As a result, fishing operations should be managed to maintain the sustainability of fisheries resources and nutrition and food security for fishing groups (Bell *et al*., 2009).

Climate change

Without underestimating the serious consequences of human influences on fisheries, climate change is commonly considered the most serious danger to fish productivity because it interrelates with and intensifies prevailing non-climatic stressors. The impact of climate change, including changes in water temperatures, water levels, and rainfall patterns, affects fish productivity, leading to reduced fish production and lower incomes for fish producers (Islam *et al*., 2014). Although climate change is affecting fish output in Uganda, the degree of the effects on fish populations is not uniform across regions. For example, inland fisheries are more vulnerable to climate change than coastal fisheries because they rely more on external climatic factors. Climate change influences fish productivity by altering geographical distribution, fish chemistry, and biological processes such as reproduction, metabolism, and spawning activities (Nyboer *et al*., 2022).

Limited access to finance

Limited access to finance affects fish producers' ability to obtain the necessary inputs, technology, and infrastructure to increase production and improve fish quality in Uganda. The fisheries industry has been severely harmed by insufficient financial allocation within the directorate of fisheries resources, as well as minimal assistance for extension service providers and reduced fish feed/seed production. In many circumstances, research operations in aquaculture are hampered by a lack of funding, which negatively affects the quality of innovation, research, and novel aquaculture insights acquired (Atukunda and Ahmed, 2019; Adeleke *et al*., 2020).

Inadequate infrastructure

The lack of roads, storage facilities, and processing plants affects the efficiency and effectiveness of the fish value chain, making it difficult to transport, store, and process fish products in Uganda. These factors affect the quantity and quality of fish produced, as well as consumers' access to and use of fish products. Poor road networks, especially in remote areas, make it difficult for fishermen to transport their catch to markets and processing plants. This often leads to fish spoilage and wastage, reducing the overall quantity of fish available for consumption. Besides, the poor road networks make it difficult for consumers to access fish products, which leads to a decrease in demand (Jagger and Pender, 2001). Fish is a highly perishable commodity, and without proper storage facilities, much of the catch goes to waste. Inadequate storage facilities also limit fishermen's ability to stockpile their catch during periods of high production, leading to reduced fish supply during low-production periods. Furthermore, fish processing plants are limited. The few processing plants that exist are often located far from fishing communities, which makes it difficult for fishermen to transport their catch for processing. In addition, the existing processing plants are often poorly equipped and lack the necessary machinery to handle large volumes of fish. As a result, much of the fish produced in Uganda is sold fresh, which limits the potential for value-added products such as fish meals (Eyayu *et al*., 2023).

FUTURE PROSPECTS

Uganda’s prospects for fish production and consumption remain promising, but realizing them will require stronger alignment among sector growth, policy support, and nutrition goals. If the recent production growth trajectory is maintained, Uganda could surpass 1 million tons of annual fish production within the next decade, but gains in per capita consumption will remain modest unless post-harvest losses are reduced, domestic distribution improves, and affordable fish products reach poorer households more consistently. The most feasible and high-impact priorities for Uganda are to expand sustainable aquaculture, improve access to quality feed and seed, reduce post-harvest losses through cold-chain and market infrastructure, and strengthen regulation against overexploitation. Greater emphasis should also be placed on value addition and targeted measures that improve the affordability and accessibility of fish for low-income and rural households, so that production growth translates more directly into better nutrition outcomes. These priorities are consistent with Uganda’s fisheries and aquaculture policy direction and support SDG 2 on zero hunger, SDG 1 on poverty reduction, SDG 12 on responsible production and consumption, and SDG 14 on the sustainable use of aquatic resources.

CONCLUSION

This study sought to examine trends in, and the status of, fish and fishery product production and consumption in Uganda, and to highlight their implications for food and nutrition security. It can be concluded that fisheries have significant potential to contribute to Uganda's food and nutrition security by providing a rich, affordable supply of animal protein and essential nutrients, particularly for the most disadvantaged and vulnerable groups. Most people in Uganda rely on the aquaculture industry for a living, and it accounts for 50% of the protein consumed by Ugandans. The association between protein consumption and fish production in Uganda highlights the critical role of fish in meeting the population's protein needs, thereby ensuring food and nutrition security. However, the reliance on fish for protein also poses challenges, including overfishing and disparities in fish consumption across socioeconomic groups and regions. These challenges call for policies and interventions that promote sustainable fish production practices. Enablers and constraints of fish production and consumption in Uganda influence the sustainability and effectiveness of the fisheries sector. It is essential to address the constraints to promote sustainable fish production practices, improve the efficiency of the fish value chain, and enhance the accessibility, affordability, and availability of fish and fishery products to all Ugandans.

CONFLICT OF INTERESTS

The authors declare that they have no conflict of interest.

REFERENCES

Adeleke, B., Robertson-Andersson, D., Moodley, G., & Taylor, S. (2020). Aquaculture in Africa: A comparative review of Egypt, Nigeria, and Uganda vis-a-vis South Africa. *Reviews in Fisheries Science & Aquaculture*, *29*(2), 167-197.

Ahern, M. B., Thilsted, S. H., Kjellevold, M., Overå, R., Toppe, J., Doura, M., Kalaluka, E., Wismen, B., Vargas, M., & Franz, N. (2021). Locally-procured fish is essential in school feeding programmes in sub-Saharan Africa. *Foods*, *10*(9), 2080.

Ahmad, N. I., Wan Mahiyuddin, W. R., Tengku Mohamad, T. R., Ling, C. Y., Daud, S. F., Hussein, N. C., Abdullah, N. A., Shaharudin, R., & Sulaiman, L. H. (2016). Fish consumption pattern among adults of different ethnics in Peninsular Malaysia. *Food \& Nutrition Research*, *60*(1), 32697.

Akena, P. R., & Mwesigwa, D. (2021). *Ideas matter: Using aquaculture technology to enhance smart farming in Lira city, mid-north*. *9*(2), 51-58.

Aklakur, M., Bakli, S., Deo, A. D., Singh, D. K., & Pailan, G. H. (2023). Cyanobacteria toxicity in aquaculture system and its impact on fish physiology. *Journal of Aquaculture & Marine Biology*, *12*(1), 28-33. https://doi.org/10.15406/jamb.2023.12.00353.

Akuffo, A. S., & Quagrainie, K. K. (2019). Assessment of household food security in fish farming communities in Ghana. *Sustainability*, *11*(10), 2807.

Amoda, O., Abiodun, O., & Adewale, C. (2025). Phytoplankton diversity and their relationship with water quality parameters in the middle basin of Ogun River, Abeokuta, Southwest Nigeria. *Acta Agraria Debreceniensis*, 2, 5-13.

Atukunda, G., & Ahmed, M. (2019). Analysis of incentives and disincentives for fish in Uganda. *Gates Open Res*, *3*(1322), 1322.

Aumeistere, L., Ciproviča, I., Zavadska, D., & Volkovs, V. (2018). Fish intake reflects on DHA level in breast milk among lactating women in Latvia. *International Breastfeeding Journal*, *13*(1), 1-8. https://doi.org/10.1186/s13006-018-0175-8.

Balirwa, J. S., & Kamanyi, J. R. (2005). The fish stocks in Uganda aquatic systems: opportunities and challenges for transformation. SIDALC. Retrieved from http://hdl.handle.net/1834/35343.

Bell, J. D., Kronen, M., Vunisea, A., Nash, W. J., Keeble, G., Demmke, A., Pontifex, S., & Andréfouët, S. (2009). Planning the use of fish for food security in the Pacific. *Marine Policy*, *33*(1), 64-76.

Béné, C., & Heck, S. (2005). *Fish and food security in Africa*. Africa and West Asia Programme. WorldFish Center - Egypt P.O. Box 1261, Maadi, Cairo, Egypt.

Benjakul, S., Yarnpakdee, S., Senphan, T., Halldorsdottir, S. M., & Kristinsson, H. G. (2014). Fish protein hydrolysates: production, bioactivities, and applications. In *Antioxidants and Functional Components in Aquatic Foods* (pp. 237–281). Wiley Online Library.

Bhujel, R. C. (2024). Global aquatic food production. In *Aquatic food security* (pp. 99-126). GB: CABI.

Boto, I., Phillips, S., & Mariaeleonora, D. (2013). *Fish-farming: the new driver of the blue economy*.

Canty, S. W. J., & Deichmann, J. L. (2022). Do small-scale fisheries have the capacity to provide food security to coastal populations? *Fish and Fisheries*, *23*(3), 708-718.

Chan, C. Y., Tran, N., Pethiyagoda, S., Crissman, C. C., Sulser, T. B., & Phillips, M. J. (2019). Prospects and challenges of fish for food security in Africa. *Global Food Security*, *20*, 17-25.

Christian, A. K., & Dake, F. A. A. (2022). Profiling household double and triple burden of malnutrition in sub-Saharan Africa: prevalence and influencing household factors. *Public Health Nutrition*, *25*(6), 1563-1576.

De Schutter, O., Jacobs, N., & Clément, C. (2020). A 'Common Food Policy for Europe: How governance reforms can spark a shift to healthy diets and sustainable food systems. *Food Policy*, *96*, 101849.

Egerton, S., Wan, A., Murphy, K., Collins, F., Ahern, G., Sugrue, I., Busca, K., Egan, F., Muller, N., Whooley, J., & others. (2020). Replacing fishmeal with plant protein in Atlantic salmon (Salmo salar) diets by supplementation with fish protein hydrolysate. *Scientific Reports*, *10*(1), 4194.

Eyayu, A., Getahun, A., & Keyombe, J. L. (2023). A review of the production status, constraints, and opportunities in East African freshwater capture and culture fisheries. *Aquaculture International*, *31*(4), 2057-2078.

FAO FishStatJ (2025) Software for Fishery and Aquaculture Statistical Time Series. Retrieved from https://www.fao.org/fishery/en/statistics/software/fishstatj. Accessed on 6 May 2025

FAO (2011). FAO/INFOODS global food composition database for fish and shellfish, version 1.0 - uFiSh1.0. Retrieved from https://openknowledge.fao.org/items/61bfa2e6-ce2f-443e-8915-9d648bb12ad5.

FAO (2019). *Fisheries and aquaculture country profiles: Uganda*. Food and Agricultural Organization. Retrieved from https://www.fao.org/fishery/facp/uga/en.

FAO (2020). The State of World Fisheries and Aquaculture 2020; Opportunities and challenges. Retrieved from https://openknowledge.fao.org/items/b752285b-b2ac-4983-92a9-fdb24e92312b.

FAO (2022a). The State of World Fisheries and Aquaculture 2022. In *FAO*. FAO. https://doi.org/10.4060/cc0461en.

FAO. (2022b). Utilization and processing of fisheries and aquaculture production. *Food and Agricultural Organization of the United Nations*. https://www.fao.org/3/cc0461en/online/sofia/2022/utilization-processing-fisheries-production.html.

FAO. (2023). Uganda Aquaculture Sector Overview. Text by Mwanja, W.W. *Fisheries and Aquaculture Division [online]*. Rome. Retrieved from https://www.fao.org/fishery/en/countrysector/ug/en.

Fiorella, K. J., Milner, E. M., Bukusi, E., & Fernald, L. C. H. (2018). Quantity and species of fish consumed shape breast-milk fatty acid concentrations around Lake Victoria, Kenya. *Public Health Nutrition*, *21*(4), 777-784.

Ghaly, A. E., Ramakrishnan, V. V, Brooks, M. S., Budge, S. M., & Dave, D. (2013). Fish processing wastes as a potential source of proteins, amino acids, and oils: A critical review. *Journal of Microbial and Biochemical Technology*, *5*(4), 107-129.

Gil, A., & Gil, F. (2015). Fish, a Mediterranean source of n-3 PUFA: benefits do not justify limiting consumption. *British Journal of Nutrition*, *113*(S2), S58-S67.

Gladyshev, M. I., & Sushchik, N. N. (2019). Long-chain omega-3 polyunsaturated fatty acids in natural ecosystems and the human diet: Assumptions and challenges. *Biomolecules*, *9*(9), 1-16. https://doi.org/10.3390/biom9090485.

Grandjean, P., Satoh, H., Murata, K., & Eto, K. (2010). Adverse effects of methylmercury: Environmental health research implications. *Environmental Health Perspectives*, *118*(8), 1137–1145. https://doi.org/10.1289/ehp.0901757.

Greene, J., Ashburn, S. M., Razzouk, L., & Smith, D. A. (2013). Fish oils, coronary heart disease, and the environment. *American Journal of Public Health*, *103*(9), 1568–1576. https://doi.org/10.2105/AJPH.2012.300959.

Hamad, A., & Tayel, A. (2025). Food 2050 concept: Trends that shape the future of food. *Journal of Future Foods*, 6(6), 1053-1066.

Hambrey, J. (2017). The 2030 Agenda and the sustainable development goals: the challenge for aquaculture development and management. *FAO Fisheries and Aquaculture Circular*, *C1141*.

Hasselberg, A. E., Aakre, I., Scholtens, J., Overå, R., Kolding, J., Bank, M. S., Atter, A., & Kjellevold, M. (2020). Fish for food and nutrition security in Ghana: Challenges and opportunities. *Global Food Security*, *26*, 100380.

Hishamunda, N., Ridler, N., & Martone, E. (2014). Policy and governance in aquaculture: lessons learned and the way forward. *FAO Fisheries and Aquaculture Technical Paper*, *577*.

Hosomi, R., Yoshida, M., & Fukunaga, K. (2012). Seafood consumption and components for health. *Global Journal of Health Science*, *4*(3), 72-86. https://doi.org/10.5539/gjhs.v4n3p72.

Hyuha, T., Ekere, W., Egna, H., & Molnar, J. (2017). Social and economic performance of tilapia farming in Uganda. *FAO Fisheries & Aquaculture Circular*, (1130).

IPC. (2020). Uganda: Acute Food Insecurity Situation. Integrated Food Security Phase Classification. https://www.ipcinfo.org/ipc-country-analysis/details-map/en/c/1152896/?iso3=UGA.

Islam, M. M., Sallu, S., Hubacek, K., & Paavola, J. (2014). Vulnerability of fishery-based livelihoods to the impacts of climate variability and change: insights from coastal Bangladesh. *Regional Environmental Change*, *14*, 281-294.

Jagger, P., & Pender, J. (2001). Markets, marketing and production issues for aquaculture in East Africa: The case of Uganda. *IIFET 2000 Proceedings*. Retrieved from https://ir.library.oregonstate.edu/concern/conference_proceedings_or_journals/2801ph212.

Kasozi, N., Rutaisire, J., Nandi, S., & Sundaray, J. K. (2017). A review of Uganda and India's freshwater aquaculture: Key practices and experience from each country. *Journal of Ecology and The Natural Environment*, *9*(2), 15–29. https://doi.org/10.5897/jene2016.0615.

Kawarazuka, N., & Béné, C. (2010). Linking small-scale fisheries and aquaculture to household nutritional security: an overview. *Food Security*, *2*(4), 343–357.

Kawarazuka, N., & Béné, C. (2011). The potential role of small fish species in improving micronutrient deficiencies in developing countries: building evidence. *Public Health Nutrition*, *14*(11), 1927-1938.

Kimáková, T., Kuzmová, L., Nevolná, Z., & Bencko, V. (2018). Fish and fish products as risk factors for mercury exposure. *Annals of Agricultural and Environmental Medicine*, *25*(3), 488-493. https://doi.org/10.26444/aaem/84934.

Kwasek, K., Thorne-Lyman, A. L., & Phillips, M. (2020). Can human nutrition be improved through better fish-feeding practices? a review paper. *Critical Reviews in Food Science and Nutrition*, *60*(22), 3822–3835.

MAAIF (2010). Agriculture Sector Development Strategy and Investment Plan: In *Ministry of Agriculture, Animal Industry and Fisheries (MAAIF)* (Issue March 2010).

MAAIF (2017). National Fisheries and Aquaculture Policy "Optimizing benefits from Fisheries and Aquaculture Resources for Socio-Economic Transformation (Issue July).

Mahaffey, K. R., Sunderland, E. M., Chan, H. M., Choi, A. L., Grandjean, P., Mariën, K., Oken, E., Sakamoto, M., Schoeny, R., Weihe, P., & others. (2011). Balancing the benefits of n-3 polyunsaturated fatty acids and the risks of methylmercury exposure from fish consumption. *Nutrition Reviews*, *69*(9), 493-508.

Marinda, P. A., Genschick, S., Khayeka-Wandabwa, C., Kiwanuka-Lubinda, R., & Thilsted, S. H. (2018). Dietary diversity determinants and contribution of fish to maternal and under-five nutritional status in Zambia. *PloS One*, *13*(9), e0204009.

Maulu, S., Nawanzi, K., Abdel-Tawwab, M., & Khalil, H. S. (2021). Fish nutritional value as an approach to children's nutrition. *Frontiers in Nutrition*, *8*, 780844. https://doi.org/10.3389/fnut.2021.780844.

Mbowa, S., Odokonyero, T., & Munyaho, A. (2017). Harnessing floating cage technology to increase fish production in Uganda. Research Series No. 138.

Mottaleb, K. A., Fatah, F. A., Kruseman, G., & Erenstein, O. (2021). Projecting food demand in 2030: Can Uganda attain the zero hunger goal? *Sustainable Production and Consumption*, *28*, 1140-1163.

Mulu, E., & Mengistie, B. (2017). Household food insecurity and its association with nutritional status of under five children in Sekela District, Western Ethiopia: a comparative cross-sectional study. *BMC nutrition*, *3*, 35. https://doi.org/10.1186/s40795-017-0149-z.

Munguti, J., Muthoka, M., Chepkirui, M., Kyule, D., Obiero, K., Ogello, E., Madalla, N. A., & Kwikiriza, G. (2024). The fish feed sector in Kenya, Uganda, Tanzania, and Rwanda: current status, challenges, and strategies for improvement—a comprehensive review. *Aquaculture Nutrition*, *Volume 2024,* Article ID 8484451, 18 pages.

Muringai, R. T., Mafongoya, P., Lottering, R. T., Mugandani, R., & Naidoo, D. (2021). Unlocking the Potential of Fish to Improve Food and Nutrition Security in Sub-Saharan Africa. *Sustainability*, *14*(1), 318.

Musoke, R. (2021). Uganda faces serious hunger. *The Independent.* Retrieved from https://www.independent.co.ug/uganda-faces-serious-hunger/

Namubiru, Z., Aganyira, K., Van der Linden, J., & Openjuru, G. L. (2024). Sustainable fishing, lifelong learning, and youth entrepreneurship: The case of Kigungu fishing ground in Uganda. *International Review of Education*, *70*(5), 723-746.

National Geographic. (2003). *Freshwater Ecosystem*. National Geographic Society. Retrieved from https://education.nationalgeographic.org/resource/freshwater-ecosystem/.

Nettle, D., Andrews, C., & Bateson, M. (2017). Food insecurity as a driver of obesity in humans: The insurance hypothesis. *Behavioral and Brain Sciences*, *40*, e105.

NOAA Fisheries (2020). Aquaculture Supports a Sustainable Earth. Retrieved from *https://www.fisheries.noaa.gov/feature-story/aquaculture-supports-sustainable-earth*.

Nyboer, E. A., Musinguzi, L., Ogutu-Ohwayo, R., Natugonza, V., Cooke, S. J., Young, N., & Chapman, L. J. (2022). Climate change adaptation and adaptive efficacy in the inland fisheries of the Lake Victoria basin. *People and Nature*, *4*(5), 1319-1338.

Obiero, K., Meulenbroek, P., Drexler, S., Dagne, A., Akoll, P., Odong, R., Kaunda-Arara, B., & Waidbacher, H. (2019). The contribution of fish to food and nutrition security in Eastern Africa: Emerging trends and future outlooks. *Sustainability*, *11*(6), 1636.

Okocha, R. C., Olatoye, I. O., & Adedeji, O. B. (2018). Food safety impacts of antimicrobial use and their residues in aquaculture. *Public Health Reviews*, *39*, 21.

Pandey, G., & Madhuri, S. (2014). Heavy metals causing toxicity in animals and fishes. *Research Journal of Animal, Veterinary and Fishery Sciences*, *2*(2), 17-23.

Pike, I. H., & Jackson, A. (2010). Fish oil: production and use now and in the future. *Lipid Technology*, *22*(3), 59–61.

Ragasa, C., Osei-Mensah, Y. O., & Amewu, S. (2022). Impact of fish feed formulation training on feed use and farmers' income: Evidence from Ghana. *Aquaculture*, *558*, 738378. https://doi.org/https://doi.org/10.1016/j.aquaculture.2022.738378.

Rasul, M. G., & Majumdar, B. C. (2017). Abuse of antibiotics in aquaculture and its effects on humans, aquatic animals, and the environment. *The Saudi Journal of Life Sciences*, *2*(3), 8188.

Rasul, M. G., Jahan, I., Yuan, C., Sarkar, M. S. I., Bapary, M. A. J., Baten, M. A., & Shah, A. K. M. A. (2021). Seasonal variation of nutritional constituents in fish of South Asian Countries: A review. *Fundamental and Applied Agriculture*, *6*(2), 193209.

Rivera, W. M., & Qamar, M. K. (2003). *Agricultural extension, rural development, and the food security challenge*. Food and Agriculture Organization of the United Nations Rome.

Safina, N., Gertrude, A., Lawrance, O., Ronald, W., Alphonse, C., Samuel, O., Mbilingi, B., & Izaara, A. A. (2018). Profitability and viability analysis of aquaculture production in Central Uganda: a case of urban and peri-urban areas. *Asian Journal of Agricultural Extension, Economics & Sociology*, *22*(4), 1–11.

Samanidou, V. F., & Evaggelopoulou, E. N. (2007). Analytical strategies to determine antibiotic residues in fish. *Journal of Separation Science*, *30*(16), 2549-2569.

Shetty, P. (2015). From food security to food and nutrition security: role of agriculture and farming systems for nutrition. *Current Science*, *109*(3), 456-461.

Simelane, K. S., & Worth, S. (2020). Food and nutrition security theory. *Food and Nutrition Bulletin*, *41*(3), 367-379.

Smith, L. E. D., Khoa, S. N., & Lorenzen, K. (2005). Livelihood functions of inland fisheries: policy implications in developing countries. *Water Policy*, *7*(4), 359-383.

Ssegane, H., Tollner, E. W., & Veverica, K. (2012). Geospatial modeling of site suitability for pond-based Tilapia and Clarias farming in Uganda. *Journal of Applied Aquaculture*, *24*(2), 147-169.

Stronge, D., Scheyvens, R., & Banks, G. (2020). Donor approaches to food security in the Pacific: Sustainable development goal 2 and the need for more inclusive agricultural development. *Asia Pacific Viewpoint*, *61*(1), 102-117.

Subasinghe, R., Soto, D., & Jia, J. (2009). Global aquaculture and its role in sustainable development. *Reviews in Aquaculture*, *1*(1), 2-9.

Tacon, A. G. J., & Metian, M. (2013). Fish matters the importance of aquatic foods in human nutrition and the global food supply. *Reviews in Fisheries Science*, *21*(1), 22-38.

Thiao, D., & Bunting, S. W. (2022). *Socio-economic and biological impacts of the fish-based feed industry for sub-Saharan Africa* (Vol. 1236). Food & Agriculture Org.

UBOS. (2020). *Uganda Food Balance Sheets Report 2013-2018* (Issue September).

Vianna, G. M. S., Zeller, D., & Pauly, D. (2020). Fisheries and Policy Implications for Human Nutrition. *Current Environmental Health Reports*, *7*(3), 161-169. https://doi.org/10.1007/s40572-020-00286-1.

Wake, A. A., & Geleto, T. C. (2019). Socio-economic importance of Fish production and consumption status in Ethiopia: A review. *International Journal of Fisheries and Aquatic Studies*, *7*(4), 206-211.

World Health Organization. (2019). *The state of food security and nutrition in the world 2019: safeguarding against economic slowdowns and downturns* (Vol. 2019). Food & Agriculture Org.

Yazew, T., Kumsa, D., & Daba, A. (2020). Health Benefits of Fish Consumption and Its Contribution to Poverty Alleviation and Food Security in Ethiopia: A Review. *International Journal of Nutrition and Food Sciences*, *9*(4), 118-124.

Youn, S. J., Taylor, W. W., Lynch, A. J., Cowx, I. G., Beard Jr, T. D., Bartley, D., & Wu, F. (2014). Inland capture fishery contributions to global food security and threats to their future. *Global Food Security*, *3*(3-4), 142-148.