



Review

The Contribution of Fish to Food and Nutrition Security in Eastern Africa: Emerging Trends and Future Outlooks

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Abstract: Approximately 200 million people in Africa derive high-quality and low-cost proteins from fish. However, the consumption of fish is not fully exploited to combat the “triple burden” of malnutrition—obesity, undernutrition, and micronutrient deficiencies which are the leading causes of poor health in the region. There is still limited knowledge on quantitative information to guide policy makers in developing evidence-based actions that can improve the availability of and access to nutritious food for healthy and sustained diets among children and care givers. In this paper, we review the available literature with the aim of assessing and quantifying the extent to which fish contributes towards fighting food and nutrition insecurity in the Eastern Africa subregion. Key results reveal the region is characterized by fish supply deficits, and hence, low levels of fish consumed per person. Nonetheless, the increase in fish imports, and the growing supply of fish from aquaculture are likely to improve the per-capita fish intake. Fish trade is generally bidirectional, with exports exceeding imports in value terms, while significant challenges still hinder domestic and intra-regional fish trade. The Eastern Africa region is projected to realize increased fish consumption from 4.80 kg in 2013 to 5.49 kg by 2022. Rising population growth and income levels imply that the region will need 2.49 million tonnes of fish to fill the demand–supply gaps. We recommend that food security and nutritional programmes should recognize the potential of fish in providing essential micronutrients from the aspects of improved dietary quality, nutritional status, and general wellbeing of the region’s fast growing population.

Keywords: fish; food security; aquaculture; production; consumption; trade and marketing; Eastern Africa

1. Introduction

The United Nation’s 2030 development agenda adopted in 2015 [1] outlines 17 Sustainable Development Goals (SDGs) with a corresponding 169 targets that are expected to guide national, regional, and international agencies’ actions to achieve sustainable development over the next

decade [1]. In particular, SDG 2 aims at addressing all forms of hunger, as well as food and nutritional insecurity. Despite significant progress being made towards reducing hunger and combating malnutrition and food insecurity, significant challenges persist. The State of Food Security and Nutrition in the World (2018) revealed that over the past three years, the human population suffering from hunger has increased to levels recorded a decade ago [2]. Almost 1 billion people are food- and nutrient-insecure, posing a greater risk to diet-related non-communicable diseases [2,3]. The emerging “triple burden” of malnutrition—obesity, undernutrition, and micronutrient deficiencies—are now the leading cause of poor health globally [4,5]. Recent studies advocate for changes in global food production systems, for the provision of high-quality dietary requirements, to achieve the SDG 2 and the Paris Agreement targets [5,6].

Fish, including finfish and shellfish, contribute 17% of animal protein, and 7% of all proteins, and are crucial for over 3 billion people in developing countries [7]. Fish provides high-quality essential amino acids, docosahexaenoic and eicosapentaenoic omega-3 fatty acids, minerals, especially iron, zinc, and vitamins, often in highly bioavailable forms [6,8]. As such, fish is widely recognized as “nature’s superfood” [9]. Globally, fish consumption rates is growing faster than the global population growth, because of increased incomes and awareness of the health benefits associated with consuming fish, as well as rising urbanization [10]. In addition to directly providing high-quality food, fisheries and aquacultures create economic value through the production, trade, and marketing of wild and farmed fish [11].

Fish food is obtained from marine and freshwater-capture fisheries and aquaculture. Taken together, these fish production systems have contributed to the impressive growth of fish production within six decades, rising from 19 million metric tonnes (MT) in 1950 to 171 million MT in 2016 [7]. Global capture fisheries production peaked in 1996 at around 96 million MT. In contrast, aquaculture production has doubled every decade for the past 50 years to produce 80 million MT of food fish, 30.1 million MT of aquatic plants and 38,000 MT of non-food products in 2016 [7,12]. In 2014, aquaculture overtook capture fisheries in the provision of fish for human consumption [6,13]. As the global fastest growing food production sector, the future expansion of fish as food is expected to come from aquaculture in the next decades. According to the OECD-FAO Agriculture Outlook global fish production will increase by more than 1% p.a. over the next decade to 195 MT by 2027, owing to an increase in aquaculture production [14]. Indeed, the outlook projects a 30.1% growth in aquaculture production, equivalent to 24 MT between 2018 and 2027, which will result in aquaculture surpassing capture fisheries production in 2020 [14]. However, food fish availability can also be increased through reductions in post-harvest losses and waste.

The fisheries and aquaculture sectors in Africa are increasingly contributing to food and nutrition security, foreign exchange, employment, and livelihood support services [15]. The New Partnership for Africa’s Development (NEPAD) estimates that total fishery production in the region stands at 10.4 million tonnes [16] comprising of 6.0 million tonnes from marine capture fisheries, 2.8 million tonnes from inland water fisheries, and about 1.6 million tonnes from aquaculture. Currently, more than 30% of the continent’s population, or roughly 200 million people, consume fish as the main animal protein source and micronutrition [16]. Besides, 12.3 million people in Africa work in the fisheries and aquaculture sector, with 6.1 million (50%) being employed as fishers, 5.3 million (42%) as processors and 0.9 million (8%) as fish farmers [15]. In terms of economic value, fish produces an estimated total of US\$24 billion annually, accounting for 1.26% of gross domestic product (GDP) [16].

However, the continent continues to be burdened with numerous problems that are impeding long-term resource sustainability, reducing prospects for increasing its contribution to food security, poverty alleviation, and wealth creation [16]. Sub-Saharan Africa had the highest proportion of undernourished people globally, accounting for 25% (224 million people) in 2016 [17]. Aquaculture in Africa is still in its infancy and is practised in only a few countries fetching an estimated US\$3 billion annually [15]. Although the aquaculture industry in the continent is growing faster than any other part of the world, Africa contributes least to the amount of fish produced, consumed, and traded

globally [18–20]. For instance, aquaculture contributed 17% of total fish production in Africa, which is equivalent to a paltry 2.5% of global fish production in 2016 [7]. Taken against the backdrop of wider regional food insecurity and a projection that Africa's population will double by 2050 [21], aquaculture is poised to play an important role in providing valuable animal protein foods to poor and food-insecure populations [22–24]. Considering that 33% of the wild fish stocks are overexploited [7], aquaculture will play a critical role in meeting increased fish demand in Africa [25].

Since aquaculture in Sub-Saharan Africa is young and growing, the sector is experiencing complex socio-economic and environmental impacts that require systematic quantitative assessment and monitoring approaches toward achieving evidence-based policy planning. However, there are still gaps in quantitative information to guide decision-makers in formulating national and regional policies to optimize synergies between the socio-economic development and environmental performance of the sector. The Fisheries and Aquaculture Department of the Food and Agriculture Organization (FAO) acknowledges that quantitative information on aquaculture's socioeconomic and environmental performance is scattered in the literature, "leading to underutilization and sometimes misuse of available information". In this paper, we present current knowledge to guide national and regional policy formulation and implementation in Eastern Africa (EA) subregion. Given the recognition of fish as "nature's superfood", crucial in alleviating malnutrition in all its forms, we reviewed published information to inform the policies that recognize tradeoffs and synergies that are aimed at tackling food insecurity and malnutrition in the region. The paper synthesizes current information on the extent to which fish contributes to food and nutrition security by highlighting recent production trends, consumption, and trade in the EA subregion.

2. Methods

In this study, we used a combination of tools and models to assess the performance of the fisheries and aquaculture sector, to provide national, regional and global projections on fish supply and demand. First, we used two user-friendly data tools: (i) the World Aquaculture Performance Indicators (WAPI) Production Module [26], and (ii) the WAPI Fish Consumption Module [27], to assess and monitor aquaculture sector performance. The tools compile, package, and disseminate data and information collected from various sources to assist in evidence-based policymaking in fisheries and aquaculture. The WAPI Production module analyses the volumes and values of over 650 freshwater and marine species in nearly 250 countries over the past seven decades, from 1950 to 2016 [26]. On the other hand, the WAPI Fish Consumption Module examines food supply and utilization patterns and monitors three nutrition and seven food indicators in 270 countries over a specified timeframe [27]. Second, data on the production, consumption, and trade projections for fish and seafood from 2018 to 2027 were obtained from the OECD–FAO Agricultural Outlook report [14]. Third, we used data from the short-term projection model developed by FAO's Fisheries and Aquaculture Department, to assess and monitor potential future national, regional, and global fish supply and demand, as well as to estimate aquaculture stopgap requirements, to fulfill supply [28]. This short-term model estimates: (i) growth in fish demand, due to income and population growth; (ii) growth in the supply trends from aquaculture; and (iii) other indicators that measure demand-supply gaps [28]. Finally, we reviewed long-term fish projections in the updated version of the International Model for Policy Analysis of Agriculture Commodities and Trade (IMPACT), developed by the International Food Policy Research Institute (IFPRI), in collaboration with WorldFish, FAO's Fisheries and Aquaculture Department, and the University of Arkansas at Pine Bluff [29,30]. Apart from these models and tools, we also scoped for information in published research in peer-reviewed articles, books, book chapters, thesis/dissertations, and conference proceedings.

3. Results

3.1. Fish Production

Historically, Africa's fisheries output is dominated by capture fisheries, but the contribution of aquaculture to the total amount of fish produced in the region has grown at a steady pace over the past decade [19]. In the Eastern Africa region countries comprising Burundi, Ethiopia, Kenya, Rwanda, Uganda, and Tanzania, fish is produced from freshwater inland and marine capture fisheries and aquaculture [31]. These three sources of fish play complementary roles in: (a) supporting rising fish demand, and (b) improving incomes and food and nutrition security of smallholder producers, fishers and consumers in rural and urban areas. The inland capture fishery sectors provide most of the sub-regions' fishery production (Table 1). However, fish catches from wild sources have been declining, due to multiple anthropogenic pressures including climate change, overfishing, habitat destruction, invasion of non-native species, illegal, unreported, and unregulated fishing (IUU), and poor governance [32–34].

Taken together, aquaculture production in the EA subregion is relatively small, compared to the top producers in Africa—Egypt (c. 1.37 million tonnes) and Nigeria (c. 306,727 tonnes) [26] (Table 1). Aquaculture production is dominated by tilapia farming, which is also the most popular fish from a consumer perspective [35,36]. Uganda has the highest aquaculture production of 118,000 tonnes harvested from 25,000 ponds covering 10,000 hectares in 2016 [37]. Kenya is also a regional player in the growth of aquaculture, as the fourth largest producer of farmed fish in Africa, having experienced a significant growth from 4452 tonnes in 2008 to a peak at 24,096 tonnes in 2014, spurred by a large-scale aquaculture subsidy programme under the Economic Stimulus Programme (ESP) from 2009–2013 [38]. In Burundi, Ethiopia and Tanzania, aquaculture contributes <10% to the total fish production; thus, more attention is needed to prioritize the development of the sector in these countries, taking advantage of the diverse aquatic resources that support fish production. Generally, the increase in aquaculture production in the region has been attributed to increased levels of investment by the private sector, and deliberate public-sector interventions [31,36]. It is anticipated that increase in fish supplies from aquaculture will contribute to achieving hunger-free and food, and nutrition secure nations.

Table 1. Capture and aquaculture production of fish in the EA subregion in 2016.

Country	Capture Fisheries Production (Tonnes)	Aquaculture Production (Tonnes)	Total Domestic Fish Supply (Tonnes)	Aquaculture as a Share of Fish Production (%)
Sub-Saharan Africa	7,254,848	592,540	7,847,388	7.8
Egypt	335,613	1,370,660	1,706,273	81.73
Nigeria	734,731	306,727	1,041,458	30.62
Burundi	20,120	1,326	21,446	6.2
Ethiopia	45,519	91	45,610	0.2
Kenya	165,135	18,658	183,793	11.3
Rwanda	29,334	4,847	34,181	14.2
Tanzania	371,228	10,742	381,970	2.8
Uganda	396,205	117,590	513,795	22.9

Data Source: WAPI-AQPRN v.2018.1 [26]

3.2. The Food Security Situation in Eastern Africa

The economic performance indicators vary significantly across the EA subregion. Ethiopia and Kenya are the dominant economies in the region, with an average GDP growth of 6.2% in 2018, being projected to grow to 6.4% in 2019 and 6.5% in 2020, due to large infrastructure investments and growing domestic markets [39]. Agriculture is East Africa's most important sector, supporting livelihoods of over 80% of the region's population. Despite this crucial role, almost all countries (except Ethiopia)

have not achieved at least 10% of the budget allocation towards agriculture and rural development, according to the Maputo Declaration [40]. Due to the low capital investments in the agricultural sector, millions of people continued to suffer from malnutrition in all its forms, with significant social and economic impacts [41].

With a total population close to 300 million—almost a quarter of Africa’s population—East Africa was the second sub-region after Southern Asia, having the highest food insecure population in 2016 [2,40]. Recent reports have revealed that between 2015 and 2017, about 72.9 million people were undernourished, 2.7 million children below five years old were affected by wasting, 14.7 million children below five years old were stunted, and 1.5 million children under five years old were overweight in the region [2]. Indeed, Table 2 reveals that the prevalence of malnutrition was higher among children under five years of age than the World Health Organization (WHO) recommended thresholds [42]. Although Burundi has the highest prevalence (55%) of children under five years old who are stunted in the world; Ethiopia, Kenya, Tanzania, and Uganda—fall within the top 20 countries, having a high number of undernourished people [41]. The high malnutrition incidences in the region correspond to a low quantity of fish consumed/capita, which was estimated at 5.3 kg in 2013 (Table 4) and the lower average per capita caloric intake (2205 kcal/capita/day), compared to the global average intake of 2,900 kcal/capita/day (Table 2). Yet, fish is widely recognized as a rich source of essential fatty acids, especially docosahexaenoic acid (DHA), minerals, vitamins, and essential amino acids [6,43], which are required for improved health, especially in supporting physical and mental development and functioning [43]. The consequences of malnutrition are severe economically, considering that over 20% of the population are unable to acquire sufficient and quality food to meet their dietary requirements.

Table 2. Population, economic indicators, and hunger dimensions for Eastern Africa counties.

Economic	Burundi	Ethiopia	Kenya	Rwanda	Tanzania	Uganda	World
Population (in millions) 2016	10.9	105.0	49.7	12.2	57.3	42.9	7,550.3
Gross Domestic Product (Current UD\$, billions)	3172	80,562	79,263	9135	52,090	25,995	
Rural population, total (millions)	10.0	82.7	36.1	9.1	37.1	35.6	3,373.5
Government expenditure on agriculture & fishing (% total outlays)	2.8	15.9	1.5	3.0	1.1	4.0	-
Employment in agriculture sector (including fisheries and aquaculture) %	96.4	69.0	38.1	66.9	67.2	70.4	26.7
Hunger and malnutrition dimensions							
Average dietary energy supply (kcal/cap/day)	-	2330	2217	2203	2241	2033	2904
Prevalence of undernourishment (%)	-	21.4	24.2	36.1	32.0	41.4	10.9
Stunting in children under 5 (%)	55.9	38.4	26.0	37.9	34.4	28.9	22.7
Wasting in children under 5 (%)	5.1	9.9	4.0	2.2	4.5	3.6	7.5
Number of undernourished people (million)	n.a	21.9	11.7	4.3	17.8	17.2	803.1
Number of wasted children < 5 years (million)	0.1	1.5	0.3	<0.1	0.4	0.3	50.5
Number of stunted children < 5 years (million)	1.1	5.8	1.8	0.6	3.2	2.2	150.8
Number of overweight children <5 (million)	<0.1	0.4	0.3	0.1	0.3	0.3	38.5

Data Source: FAO Statistical Pocketbook [41], WAPI- FISHCSP v.2018.1 [27] and UN-DESA [21].

Recently, [44] proposed a reference flexitarian diet to include 28g of fish/day to provide essential omega 3 fatty acids that are critical in reducing the risks of heart disease. More importantly, increasing the consumption of fish, especially nutrient-rich small fish, among pregnant and lactating women and small children can make a real difference in the nutritional wellbeing of poor communities [45–47]. In Kenya, for instance, a study on the contribution of fish farming to the reduction of undernutrition in children (< 5 years) within households and communities in the Central Province of Kenya revealed that the “weight for age” and “height for age” were significantly higher in children from fish farming

households than those who live on farms without any access to fish farming [48]. This suggests that children living among fish farming families are more nutritionally favored. The study is consistent with results from Malawi, which reported lower prevalence of stunting and underweight children living among fish-farming than non-fish-farming households [49].

3.3. Contribution of Fish to Food and Nutrition Security

Several publications recognize the full potential of fish in improving the food and nutritional security of the rural poor, especially of women and young children [45,47,50,51]. In per capita terms, global fish consumption increased at an average of about 1.5% per year from 9.0 kg in 1961 to 20.2 kg in 2015 [7]. The amount of fish consumed globally is projected to increase to an average of 21.3 kg in 2027 from 20.5 kg, in the 2015 to 2017 period [14]. Africa's fast-growing human population outstrips growth in fish supply, and most of the continent's wild fish populations are fully exploited. Therefore, aquaculture production must more than double by 2050 to satisfy the projected fish demand [28]. Despite fish providing 19% of animal protein intake in Africa, the annual per capita fish consumption remains lower than the global levels [25]. The key driving forces behind increased fish consumption are rapid population growth, rising incomes, urbanization, a growing appreciation of healthy and nutritious fish-based food, and innovations in processing and packaging technologies and distribution channels [10,14].

Eastern African region exhibits remarkably low levels of fish consumption per capita (average of 5.3 kgs) compared to the rest of Africa (10.1 kg), and global level of 19.8 kg (Table 3). On a positive note, it is the only subregion that has had an increase in per capita consumption, and in the share in world fish consumption, from 1.08% to 1.26% between 2008 and 2013 [28]. In per capita terms, only Uganda's per capita fish consumption of 12.5 kg was higher than the rest of Sub-Saharan Africa. Although there was a significant proportion of protein intake among households in the EA subregion from animal sources; the per capita intake was far less than the world's average of 32 g/capita/day [27]. More importantly, the percentage share of fish in animal protein intake in Burundi, Rwanda, Tanzania, and Uganda was more than the world average, signifying the crucial role that fish plays in food and nutrition security, in a region characterized by a low consumption of animal proteins. The main reasons driving fish preferences and consumption are low prices (average of US\$2/kg), an awareness of fish as a healthy food source, changing consumer tastes and preferences, the mode of processing, the ease of preparation, and the nutritional value of fish [52,53].

Table 3. The fish, animal, and total protein intake across Eastern African countries in 2013, compared to Africa and the global status.

Region/Countries	Population (Thousands)	Total Food Fish Supply (Tonnes)	Fish Consumption (kg/Person/Year)	Fish Protein (g/Person/Day)	Animal Protein (g/Person/Day)	Fish/Animal Protein (%)	Fish/Total Protein (%)
World	7,162,118	142,126,714	19.8	5.4	32.1	16.9	6.7
Africa	1,110,636	11,225,497	10.1	2.9	16.0	18.4	4.4
Burundi	10,163	20,145	2.0	0.6	2.2	28.1	1.7
Ethiopia	94,101	39,347	0.4	0.1	7.7	1.6	0.2
Kenya	44,354	181,227	4.1	1.2	15.8	7.3	1.9
Rwanda	11,777	52,910	4.5	1.5	5.8	25.1	2.5
Tanzania	49,253	352,304	7.2	2.3	10.4	22.5	4.0
Uganda	37,579	469,773	12.5	3.7	12.4	30.1	7.1

Data Source: UN-DESA [21] and WAPI- FISHCSP v.2018.1 [27]

Fish is often considered to be a 'rich food for poor people' [8]. Fish is the most accessible and affordable source of animal protein, providing many of the key nutrients and calories that are needed for physical and mental development [54]. For example, analysis by [55] on the consumption patterns of different types of proteins in Kenya show that wild-caught, followed by pond fish, make up a large proportion of the total protein that is consumed by respondents from 'poor' socioeconomic classes (Figure 1). The results further indicate that as households become wealthier, "terrestrial

sources of animal protein” (e.g., chicken, beef, mutton and pork) occupy increasingly larger shares of total protein consumption. Conversely, as socioeconomic status declines, fish becomes increasingly important. This implies that the poorer the households, the more important fish is to their total protein intake. Therefore, [55] concluded that although formidable fish supply chain issues remain, many families—including poor families—had attained meaningful food security benefits from aquaculture. As a result, more action is needed to address the economic constraints that are plaguing the sector.

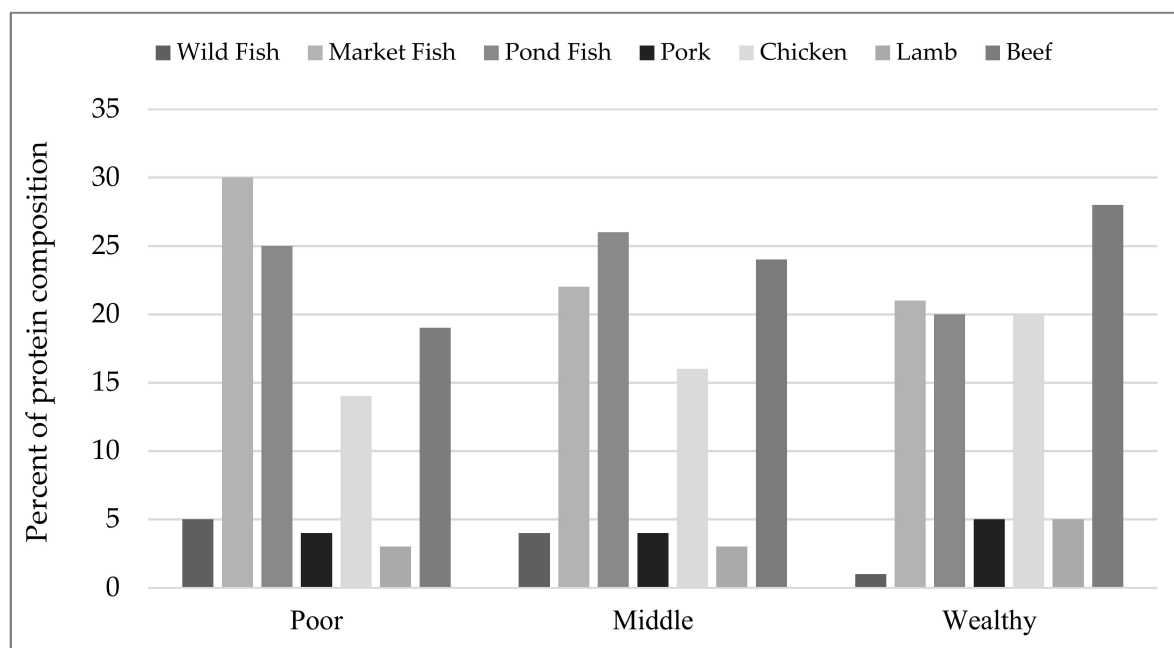


Figure 1. Protein consumption composition by socioeconomic classes according to the Kenya Bureau of Statistics (KNBS). Data modified from [55].

3.4. Fish Trade and Marketing

Fish and fishery products remain the most well traded food items worldwide [7,14]. International trade is crucial to the fisheries sector, especially in the least advanced economies, through the creation of employment, supplying food, generating income, and thus contributing to maintaining food and nutrition security [14,56]. According to [7], about 35% of the world’s fish production is traded internationally for human consumption and non-edible purposes. Over the past 40 years, the trade in fish and fish products increased significantly in value terms, from US\$8 billion in 1976, to US\$143 billion in 2016 [7]. Approximately half of the fish consumed by developed country markets, like the United States (US) and the European Union (EU) originates from developing countries [12].

Despite the relatively high contribution of developing countries to global trade, millions of people in developing countries consume fish protein in their diets, compared to those living in developed countries [12]. Furthermore, [57] demonstrated that domestic consumption accounts for approximately 90% of the total fish production in developing countries. Recent evidence further reveals that cultured fish in the Global South markets is increasingly available to poor rural and urban consumers, thus creating ‘new geographies of consumption’ [57]. These changing consumption patterns dispel widely held narratives that farmed fish is, “mostly exported to the wealthy countries of Europe and North America or consumed by the growing middle-classes in the megacities of these economies” [6]. This trend is likely to result in the diversification of product and market strategies towards smaller, cheaper and relatively more accessible fish [58,59].

The traditional focus on large export-oriented international trading blocs like the EU and US markets has meant that less attention has been paid to developing regional trade, which is thought to have great potential [60]. Empirical evidence by the United Nations Conference on Trade and

Development (UNCTAD) reveal three emerging challenges that hinder global fish trade [56]. First, fish products are relatively more affected by Non-Tariff Measures (NTMs), compared to non-fish products. Second, fish products are mostly affected by technical regulations related to sanitary and phytosanitary standards (SPS) and technical barriers to trade (TBTs) [56]. Third, most countries impose SPS regulations on imported fish products [56]. In the East African Community (EAC) and the Common Market for Eastern and Southern Africa and East African Community (COMESA) regions, the most pressing issues facing regional fisheries trade relate to non-tariff barriers such as export licensing, logistics and poor infrastructure, lack of quality assurance, and high post-harvest losses, which significantly hinder domestic and intra-regional trade [60]. Compounding these challenges is an inadequate level of knowledge or empirical evidence to inform policy development and implementation, as well as practical conduct of cross-border trade [61].

Fish trade in East Africa has become bidirectional. On one hand, fish exports exceed imports in value terms in the region, as a result of the export of premium products to higher income countries particularly in the European Union, Far East and Middle East Countries, and the United States of America [60,61]. Three East African countries (Uganda, Tanzania and Kenya) have lucrative export markets for Nile perch from capture fisheries, in addition to high-value seafood, mainly composed of frozen tuna, octopus, fillets, snappers, prawns, and lobsters caught in the Indian Ocean from Kenya and Tanzania. On the other hand, East Africa is also an importer of frozen tilapia, mackerels, sardines, prawns and salmons. Tilapia imported from China has dominated whole fish and frozen fillet forms on the East African market. Over the past five years, the value of fish exports has slightly declined, while the import value increased by 44%, driven by population increases versus declining supplies from capture fishers, a growing awareness of fish as being a healthy food in diets, and urbanization (Figure 2). Aquaculture products, especially of fresh frozen Nile tilapia, are mostly consumed locally.

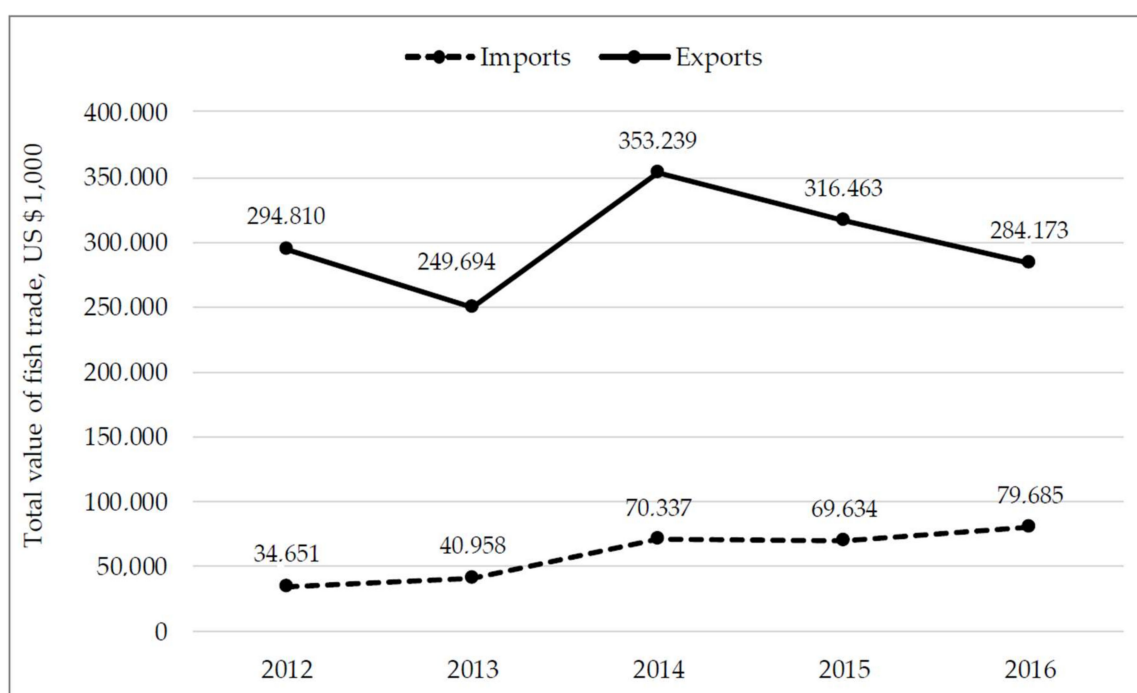


Figure 2. Total value of international imports and exports of fish and fishery commodities in East Africa (2012–2016). Data source [62].

Fish trade in the EA subregion has increased the scope and choice of fish that are available to consumers, because of improved logistics and market distribution systems, coupled with expanding aquaculture production and technological innovations. Furthermore, as the distance becomes less of a barrier to trade, wholesalers and retailers source fish from all over the world, especially from China, to

bridge the growing demand for fish in the region, against the fluctuating supply from capture fisheries and aquaculture. Consequently, fish traders rely on imported frozen fish, due to its ease of availability, steady supply, and price. This results in a dependency on the supply of imported frozen tilapia fish, which are sold in major cities and distant markets at a lower price. Price trends for imported frozen and filleted fish over the past year reveal a slight price increase for all grades of 10 kg boxed whole tilapia in Nairobi (Table 4). This translates to an average price of 1 kg of fish, at US\$2.5 per kg. In this scenario, most of the actors in the aquaculture value chain, including producers and suppliers, do not benefit, due to out-competition, since fish producers need to sell at an average price of US\$4.5 and above to break even on production costs.

Table 4. Imported frozen whole tilapia prices in Nairobi, showing changes in prices (Kenya Shillings-KES) from May 2017 to September 2018. Source: KMFRI Field Survey Data 2017 and 2018.

Grade Per 10 kg Box	Price in KES of Imported Frozen Tilapia in November 2017	Price in KES of Imported Frozen Tilapia in September 2018
100/200	1250	1350
200/300	1500	1550
300/400	1650	1850
400/600	1900	2150
600/800	2000	2350
800/1000	2200	2400
1000/UP	2250	2500

3.5. Projections of Fish Demand and Supply Gaps

Fish consumption is anticipated to increase in all continents, except in Africa. The report reveals that the current level of fish consumption of 9.9 kg during 2015–2017 in Africa may decline to 9.6 kg by 2027 [14]. Despite the projected decline in fish consumption in Africa, there is a growing demand and supply gap corresponding to a steady population growth. As such, Africa is projected to become increasingly reliant on fish importation, growing at 2.5% p.a. to contribute 43% of the total fish consumed in Sub-Saharan Africa by 2017 [14,30]. Results from the IMPACT Model projections reveal three emerging trends in Africa's fish demand and supply: (1) much lower fish consumption levels; (2) widening fish food deficits; and (3) low contributions of farmed fish to the total fish output [25]. Under the business-as-usual scenario, capture fisheries and aquaculture will experience sluggish growth, while fish consumption per capita will slightly decline from 10.1 kg in 2013 to 8.5 kg in 2030, and ultimately to 7.7 kg by 2050 [25].

Furthermore, a recent FAO study projects slight growth in fish consumption per capita, despite high population growth projections in the Eastern Africa region [28]. Between 2008–2013, the region realized the least per capita fish consumption in African. Nonetheless, there was increased fish consumption, by 2.6% from 4.22 kg to 4.79 kg (Table 5) [28]. Notwithstanding national variations, given the fixed fish prices and preferences, coupled with rising income levels, the region is projected to experience slight increases in fish consumption from 4.8 kg in 2013 to 5.49 kg in 2022 [28]. Because of the rising population growth and increasing income levels, the East African regions will need 2.49 million tonnes of fish to fill the demand–supply gaps. The demand generated by income and population growth is estimated at 584,130 tonnes annually. While regional aquaculture production was projected to grow by 6.6% p.a. from the mid-2010s to the early 2020s, it will require 30.38% (or 25.37% under conservative projections) annual growth to close the regional demand–supply gap in the next five years. Meanwhile, Ethiopia, Burundi and Tanzania would need to realize over 80% annual growth in aquaculture production to fill the demand deficit.

Table 5. Summary of demand–supply gap projections from the mid-2010s to the early 2020s in Eastern African Countries.

Country or Country Group	Baseline Scenario in the Mid-2010s			Fish Production Projection in the Early 2020s			Demand and Supply Growth from the Mid-2010s to the Early 2020s			
	Aquaculture Production (Tonnes)	Per Capita Consumption (kg)	Total Consumption (Tonnes)	Aquaculture Production (Tonnes)	Per Capita Demand (kg)	Total Demand (Tonnes)	Extra Food Fish Supply (Tonnes)	Annual Growth Rate (%)	Demand Generated by Income and Population Growth (Tonnes)	Annual Aquaculture Growth Rate Needed to Close the Demand Supply Gap (%)
SSA	662,340	8.66	8,707,270	915,060	9.78	11,184,820	272,720	7.33	2,477,550	37.17
East Africa	211,060	4.80	1,901,110	290,520	5.49	2,485,240	79,460	6.60	584,130	30.38
Burundi	230	1.92	21,880	390	2.07	27,590	160	11.08	5720	91.51
Ethiopia	80	0.24	24,560	140	0.28	32,120	50	10.44	7560	146.68
Kenya	32,830	4.34	202,570	51,320	4.95	261,470	18,490	9.34	58,900	22.81
Rwanda	1880	4.12	48,450	3460	4.79	62,900	1580	12.99	14,450	54.14
Tanzania	5280	5.48	297,650	9420	6.23	393,540	4140	12.27	95,890	80.49
Uganda	115,580	12.84	509,530	142,900	14.25	664,030	27,320	4.33	154,500	18.50

4. Conclusions and Recommendations

This paper synthesizes and provides information on the important role of fish in food security, based on production and consumption trends, trade, marketing, and future demand and supply gaps in the Eastern African region. At regional levels, fish production and supply are dominated by capture fisheries, while aquaculture production is modest compared to the top producers in Africa. Fish consumption is characterized by an increasing supply deficit, and low per capita fish protein intake. Correspondingly, the proportion of fish in animal protein intake in most countries in the region is less than the world average, signifying the crucial role that fish plays in food security and nutrition. Fish trade in the region is characterized with a steady increase in fish imports, due to fluctuating supplies from natural systems and steady population growth, as well as improved logistics reducing distance barriers and market distribution systems.

Given fixed fish prices and preferences coupled with rising income levels, the East African region is projected to realize increased fish consumption from 4.80 kg in 2013 to 5.49 kg in 2022. As a result of the rising population growth and increasing income levels, the East African regions will need 2.49 million tonnes of fish to fill the demand–supply gap. This widening demand and supply gap presents a host of new development opportunities for the smallholder farmers to invest in efficient production systems to significantly contribute to fish consumption, reducing rural poverty and unemployment. Attention should also be given to reduce post-harvest losses, which are currently estimated at over 20%, especially for the freshwater silver cyprinids, which contribute significantly to protein consumption in the region. This would involve an improvement in value chain efficiency, better infrastructure, preservation facilities and value-addition technologies, and in market information and linkages.

Based on the findings of this research, we propose further research into three main areas. First, continuous assessment and compilation of current research is needed, to fill gaps in understanding the nutritional values of the main species of fish consumed in urban and rural areas. Second, more robust projection models are needed, to better understand fish demand and supply projections beyond 2030, since the region's population is expected to double by 2050. Third, further research is required to investigate the nutritional benefits of fish consumption, and drivers of consumer taste and preferences, especially in areas where fish has not been traditionally consumed. Future studies should also focus on the types of fish that are consumed and the nutritional effects of different fish-processing methods, as well as the socioeconomic and cultural issues influencing fish consumption options.

Looking into the future, the potential for aquaculture as a new frontier for development looks bright. More public and private investments are needed to maximize aquaculture's full potential, to improve the region's food and nutrition status. Now and in the future, fish consumption may increase with increased aquaculture production and importation of fish products, provided the barriers to intra-regional trade are addressed through ratifying regional and international trade agreements. Food security and nutritional programmes should recognize the potential of fish in providing essential micronutrients for improved dietary quality, nutritional status, and the general wellbeing of the region's fast-growing population.

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