Prioritizing Policies for Driving Inclusive Agricultural Transformation: Kenya

Value Chain Deep Dive Report: Aquaculture

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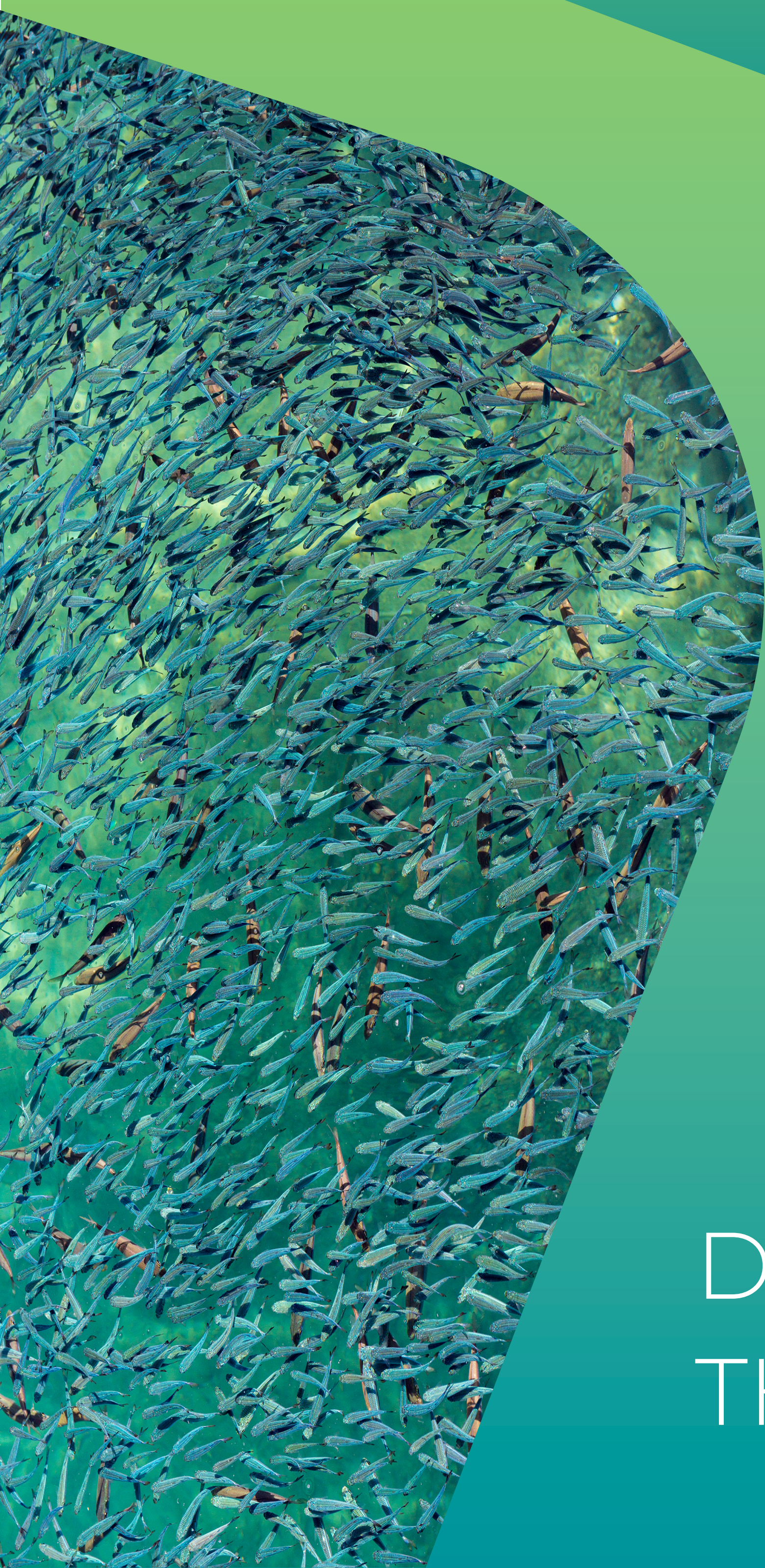

DIVING INTO THE **REPORT**

1. INTRODUCTION

The development and prioritization of appropriate and effective policies and public sector investments to drive inclusive agricultural transformation is high on the agenda in most African countries. In recent years there has been a significant shift in the policy context. Whereas the focus in the past has mainly been on increasing productivity at the farm level, the rapid rate of urbanisation and changing diets is putting greater strain on food systems, and market dynamics and private sector investment are becoming much more important.

In Kenya, the Ministry of Agriculture, Livestock and Fisheries (MoAL&F) is implementing the Agricultural Sector Transformation and Growth Strategy (ASTGS) and supporting the Presidential vision of the Big Four initiative. Both policies seek to accelerate agricultural production and agro-processing, achieve food and nutritional security, improve farmer and local community incomes, lower the cost of food, and increase employment, especially for women and young people. Under the ASTGS Flagship 8 seeks to strengthen research and innovation, with a focus on developing tools for better decision-making and supporting evidence-based policy development, planning, prioritisation and monitoring.

In response to a request for support from the Ministry, the Alliance for a Green Revolution for Africa (AGRA), in collaboration with the Bureau for Food and Agricultural Policy (BFAP), the International Food Policy Research Institute (IFPRI) and the Tegemeo Institute at Egerton University have initiated a project called the Policy Prioritisation through Value Chain Analysis (PPVC). This project uses a set of methodological tools to identify the impact of specific investment and policy interventions in value chains that have been identified under the ASTGS and Big Four Agenda. Through the PPVC approach investments and policy interventions in specific value chains can be determined and ranked according to their impact on agricultural production, employment, farm incomes, dietary and gender transformation and smallholder inclusiveness.

In a first output of the PPVC project (see Box 1), preliminary value chain scan and field investigation data were combined with Partial Equilibrium and Computable General Equilibrium modelling outputs to present a list of 12 prioritised value chains. These were ranked according to the PPVC criteria of Market Led Potential, Inclusivity, Transformation Potential and a Value Chain scan that provides qualitative information and a combined ranking on policy support, investment support, scalability and agro-ecological suitability. From the list of 12 value chains, three were chosen by the Kenyan Government for Deep Dive analysis, namely coffee, aquaculture and beef.

Box 1: Overview of the PPVC methodology[1]

The PPVC is a market-led approach that aims to:

- Assist governments with evidence-based analysis to adequately prioritise their policies and investments (e.g. the ASTGS)[2] and the accompanying National Agricultural Investment Plan (NAIP) for Kenya, Kenya Vision 2030[3], and the Big Four Presidential Agenda[4])
- Determine which policies and public investments are most (cost) effective at driving market-led inclusive agricultural transformation, and
- Involve public- and private sector stakeholders right from the start.

First, the current state or "as-is" baseline is established. For the aquaculture value chain, this provides the current state and historical trends of fish supply and demand, identifying critical stakeholders throughout the value chain, with associated market shares, operational costs, capacities and constraints, and then summarising challenges faced by the various value chain actors. Secondly, an "ideal state" for the value chain is defined, in which key bottlenecks and constraints are addressed using specific levers of change (e.g. value chain investments and policy levers). In order to reach the ideal state, a combination of investments and policies are formulated at specific nodes of the value chain aimed at unlocking more value out of the market system. Furthermore, these changes are translated to gross margin impacts at the various nodes of the value chain. The impact of interventions on the aquaculture sector is modelled over a medium-term horizon (10 years, using BFAP's partial equilibrium model) and the resulting impact on agri-food system GDP, poverty reduction and off-farm agri-food system jobs is modelled using the IFPRI RIAPA CGE modelling system.

The oceans and freshwater fisheries sector plays an important role in the Kenyan economy. It provides food, employment and income to a large share of the population, and earns vital foreign currency through high quality fish exports. Currently the sector is largely based on freshwater fisheries, with inland lakes producing close to 80% of the national output. However, freshwater fisheries production is declining mainly due to overfishing, pollution and the use of illegal fishing gear. According to the Government of Kenya (GOK, 2019 cited in KMFRI, 2021), Kenya has an estimated annual demand of 500 thousand tonnes of fish and as such an annual deficit of 365 thousand

[1] A more comprehensive overview of the PPVC methodology is included in Annexure 1

[2] The Agricultural Sector Transformation and Growth Strategy (ASTGS, 2019-2029) is a 10 year strategy aiming at developing and transforming the agriculture sector through increasing farmers' incomes, value of agricultural produce, and build households' resilience.

[3] The Kenya vision 2030 is implemented through three pillars: Economic, Social and Political. Agriculture is a key sector under the economic pillar. The goal is to attain 10% annual economic growth through transforming the sector to be highly commercially oriented.

[4] The agriculture sector contributes significantly to two agendas of the Big Four Agenda: Attainment of 100% Food Security and Nutrition and Manufacturing. Under Food Security and Nutrition, the government aims at attaining food self-sufficiency and lower the cost of food. Under manufacturing agenda, the government aims to grow the manufacturing industry through agro processing and agro-based SMEs

tonnes, which currently can only be filled through imports. According to national statistics however, local consumption has rarely exceeded the 200 thousand tonne level.

This report presents a deep dive analysis of the Kenyan aquaculture value chain and identifies a list of value-chain specific policies and public - and private sector investments that are required to drive inclusive growth and transformation in this sector. It starts with a general overview of the global, regional and Kenyan aquaculture market. This is followed by a detailed structural and economic analysis of the aquaculture sector and value chain In Kenya where a list of key policy and market related constraints are identified. The third section presents an improved state where the constraints are addressed as potential upgrades that are introduced in the form of policy and market interventions. The impacts of these interventions are quantified through a range of analytical tools, before drawing conclusions.

2. AQUACULTURE AND FISHERIES SECTOR OVERVIEW

2.1. Global context and market overview

Over the past 30 years, global fish[5] consumption has grown consistently, by an annual average of almost 2%. Post 2010, this rate accelerated further to 2.3% per annum and the OECD-FAO projects a further expansion of 1.4% per annum over the coming decade. In order to sustain this growth, aquaculture or farmed fish has increased in relative importance compared to wild-caught fish. Whilst the volume attained from capture fisheries has remained fairly stable since 1990, production from aquaculture has expanded by an annual average of 6.3%. Consequently, the share of aquaculture in total production expanded from merely 13.4% in 1990, to 46.5% by 2018 (Figure 1). The OECD-FAO projects that aquaculture's contribution to total production will continue to grow, surpassing that of capture fisheries by 2024.

Global aquaculture production is dominated by China, which accounts for almost 60% of total aquaculture production. Fish is an important source of protein in Asia, with 67% of global fish consumption and almost 90% of global aquaculture production attributed to the region (Figure 2). In terms of aquaculture production, the second largest contributing region is Europe (3.8%), followed by Latin America (3.6%) and Africa (2.6%). All three of these regions constitute a larger share of global consumption than production.

Despite China's dominance in production, it is only the second largest exporter of fish (excluding molluscs, crustaceans and other aquatic invertebrates). Figure 3 indicates that, on average between 2017 and 2019, Norway was the largest exporter, followed by Chile, Sweden and the USA. The USA, Japan, China and Sweden were the largest importers. The presence of the USA, China and

[5] Unless otherwise stated, fish refers to fish, crustaceans, molluscs and other aquatic animals, but excludes aquatic mammals, crocodiles, sea weeds & other aquatic plants.

Sweden amongst the leading importers and exporters is due to differences in processing level, optimisation of carcass value and species availability.

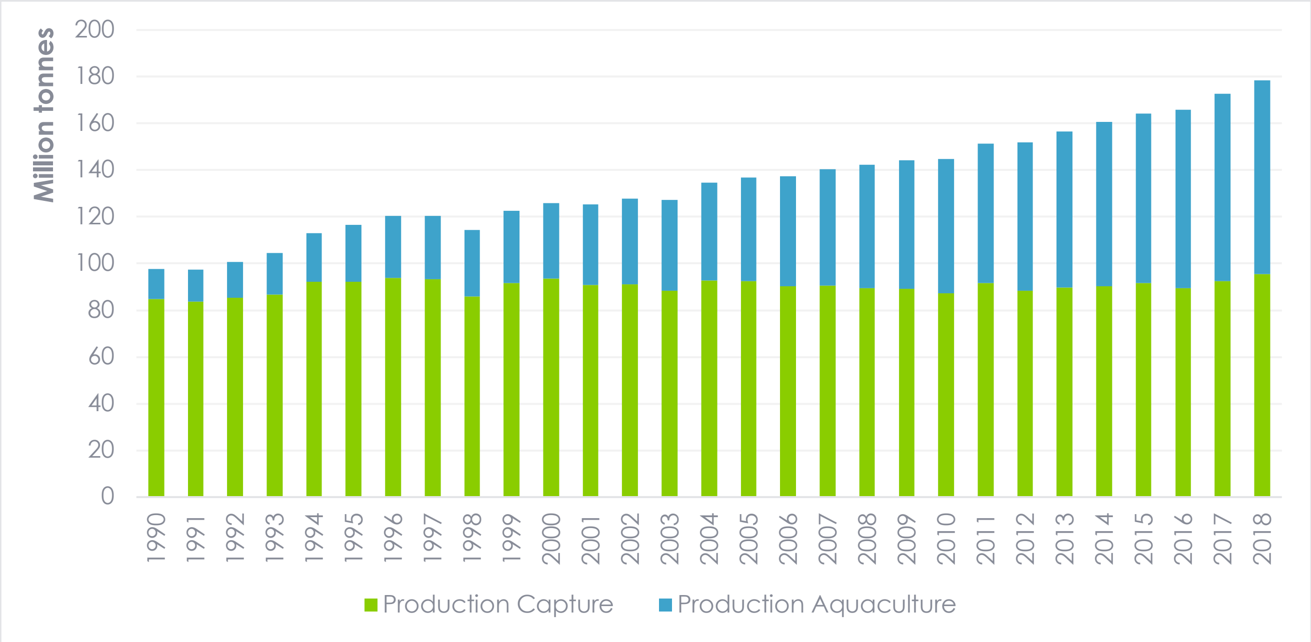

FIGURE 1: GLOBAL FISH PRODUCTION FROM CAPTURE AND AQUACULTURE

Source: Compiled from FAO Fish Stat, 2020

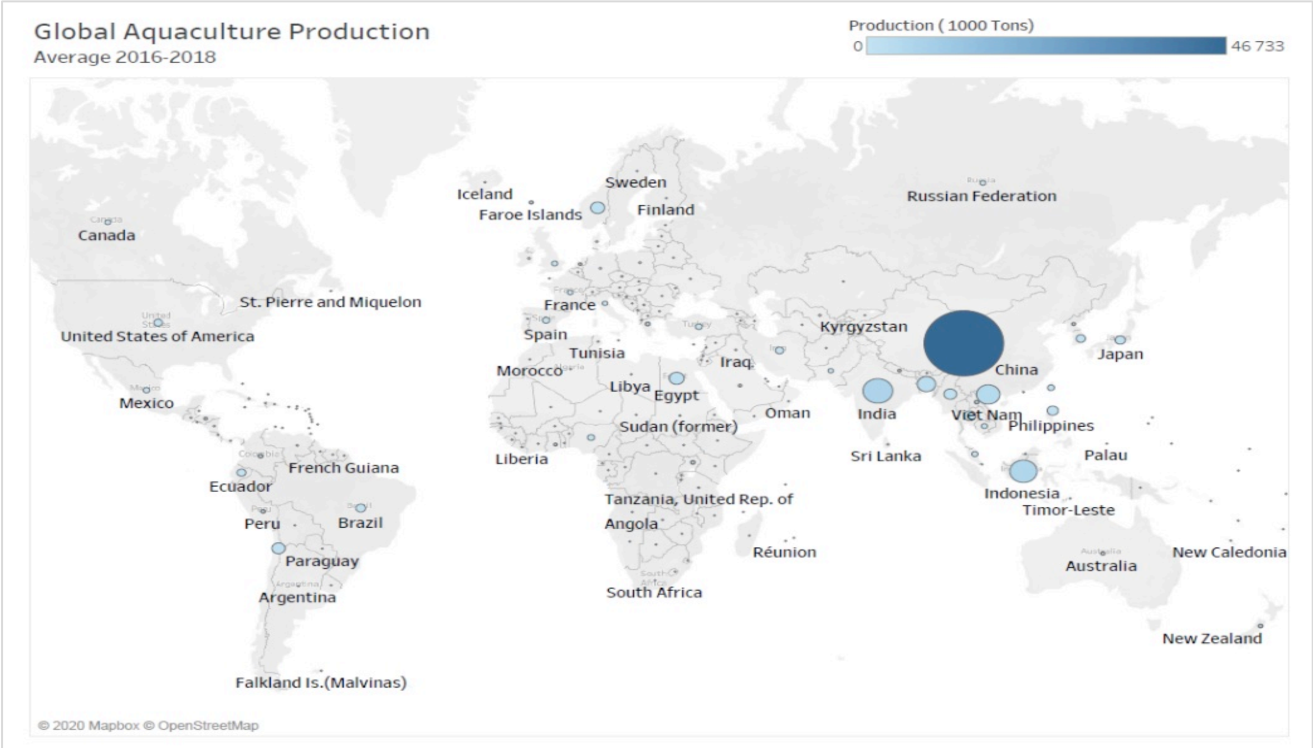

FIGURE 2: GLOBAL AQUACULTURE PRODUCTION: AVERAGE 2016-2018

Source: Compiled from FAO Fish Stat, 2020

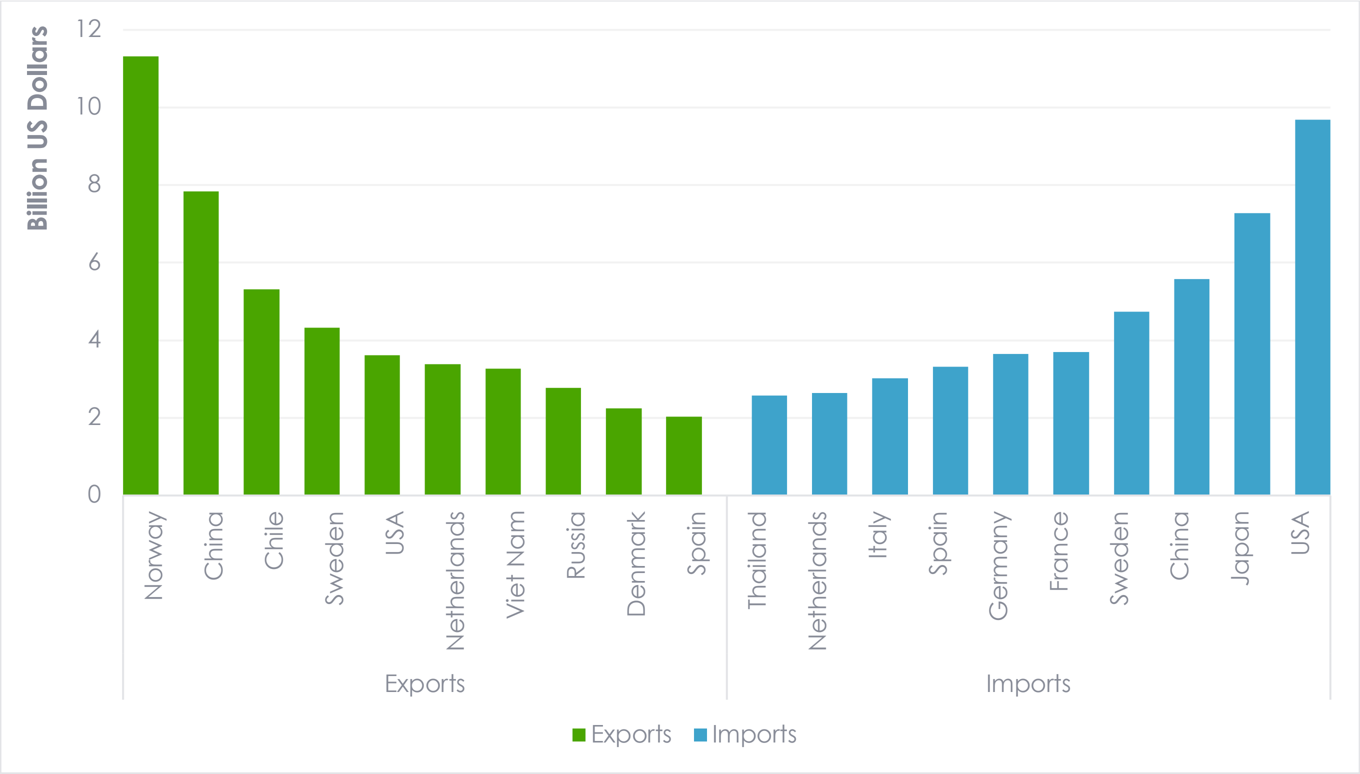

FIGURE 3: LEADING IMPORTERS AND EXPORTERS OF FISH (EXCL. MOLLUSCS, CRUSTACEANS AND OTHER AQUATIC INVERTEBRATES): AVERAGE 2017-2019

Source: Compiled from ITC Trademap, 2020

While some marine aquaculture (mariculture) is prevalent in many coastal regions of the world, the bulk of aquaculture production occurs at inland facilities. Earthen ponds remain the most commonly used production system, but tanks, pens and cages are also widely used in regions where conditions allow. The FAO (2020) notes that the growth in farming of fed animal species has outpaced unfed species, resulting in a shrinking share of unfed species in the total production mix.

Aquaculture comprises a diverse set of species in different parts of the world, but apart from Oceania, Finfish constitute the largest share of total aquaculture production in all regions. At a global level, Finfish contribute 68% of total aquaculture, followed by Molluscs (21%) and Crustaceans (10%) (FAO, 2018). While almost 600 different fish species have been recorded in aquaculture systems across the globe, a much smaller group of "staple species" accounts for the bulk of production. Within the Finfish grouping, the Grass carp, silver carp and common carp comprise the biggest share of production, at 11%, 10% and 8%, respectively, followed by the Nile Tilapia (8%) and the Bighead Carp (7%) (Table 1).

TABLE 1: MAJOR SPECIES IN AQUACULTURE GLOBALLY

Species	2010	2012	2014	2016	% of total, 2016
Finfish					
Grass carp, Ctenopharyngodon idellus	4 362	5 018	5 539	6 068	11
Silver carp, Hypophthalmichthys molitrix	4 100	4 193	4 968	5 301	10
Common carp, Cyprinus carpio	3 421	3 753	4 161	4 557	8
Nile Tilapia, Oreochromis niloticus	2 537	3 260	3 677	4 200	8
Bighead carp, Hypophthalmichthys nobilis	2 587	2 901	3 255	3 527	7
Carassius spp.	2 216	2 451	2 769	3 006	6
Catla, Catla catla	2 977	2 761	2 770	2 961	6
Freshwater fishes nei, Osteichthyes	1 378	1 942	2 063	2 362	4
Atlantic salmon, Salmo salar	1 437	2 074	2 348	2 248	4
Roho labeo, Labeo rohita	1 133	1 566	1 670	1 843	3
Pangas catfishes nei, Pangasius spp.	1 307	1 575	1 616	1 741	3
Milkfish, Chanos chanos	809	943	1 041	1 188	2
Tilapias nei, Oreochromis (=Tilapia) spp.	628	876	1 163	1 177	2
Torpedo-shaped catfishes nei, Clarias spp.	353	554	809	979	2
Marine fishes nei, Osteichthyes	477	585	684	844	2
Wuchang bream, Megalobrama amblycephala	652	706	783	826	2
Rainbow trout, Oncorhynchus mykiss	752	883	796	814	2
Cyprinids nei, Cyprinidae	719	620	724	670	1
Black carp, Mylopharyngodon piceus	424	495	557	632	1
Snakehead, Channa argus	377	481	511	518	1
Other finfishes	5 849	6 815	7 774	8 629	16
Finfish total	38 494	44 453	49 679	54 091	100
Crustaceans					
Whiteleg shrimp, Penaeus vannamei	2 688	3 238	3 697	4 156	53
Red swamp crawfish, Procambarus clarkii	616	598	721	920	12
Chinese mitten crab, Eriocheir sinensis	593	714	797	812	10
Giant tiger prawn, Penaeus monodon	565	672	705	701	9
Oriental river prawn, Macrobrachium	226	237	258	273	4
Giant river prawn, Macrobrachium rosenbergii	198	211	216	234	3
Other crustaceans	700	606	654	767	10
Crustaceans total	5 586	6 277	7 047	7 862	100
Molluscs					
Cupped oysters nei, Crassostrea spp.	3 678	3 972	4 374	4 864	28
Japanese carpet shell, Ruditapes philippinarum	3 605	3 775	4 014	4 229	25
Scallops nei, Pectinidae	1 408	1 420	1 650	1 861	11
Marine molluscs nei, Mollusca	630	1 091	1 135	1 154	7
Sea mussels nei, Mytilidae	892	969	1 029	1 100	6
Constricted tagelus, Sinonovacula constricta	714	720	787	823	5
Pacific cupped oyster, Crassostrea gigas	641	609	624	574	3
Blood cockle, Anadara granosa	466	390	450	439	3
Chilean mussel, Mytilus chilensis	222	244	238	301	2
Other molluscs	1 808	1 683	1 748	1 795	11
Molluscs total	14 064	14 874	16 047	17 139	100
Other Animals					
Chinese softshell turtle, Trionyx sinensis	270	336	345	348	37
Japanese sea cucumber, Apostichopus japonicus	130	171	202	205	22
Aquatic invertebrates nei, Invertebrata	223	128	111	97	10
Frogs, Rana spp.	82	86	97	96	10
Other miscellaneous animals	112	118	139	193	21
Other animals total	818	839	894	939	100

2.2. Regional context and market overview

Though still small compared to international norms, aquaculture has seen tremendous growth in Africa since the early 2000s. Production is dominated by North and West Africa with these two regions contributing an estimated 89% of Africa's production from 2010 to 2018. Egypt is by far the largest aquaculture producer in Africa, and during the 2016-2018 period, it produced 70% of Africa's aquafarm produce, focusing mainly on Tilapia, mullet and carp. In Nigeria, Africa's most populous country and second largest aquaculture producer, fish is a major food source, making up an estimated 40% of the country's protein intake.

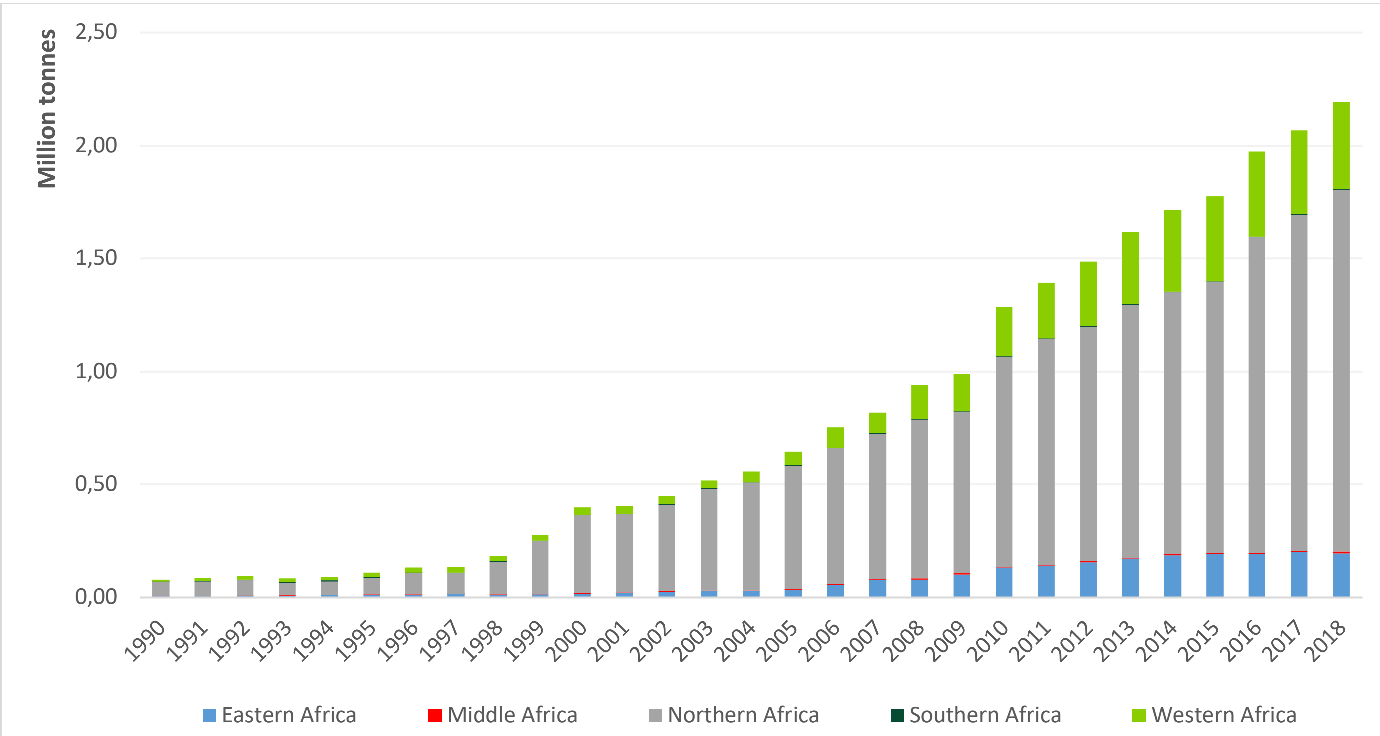

FIGURE 4: REGIONAL AQUACULTURE PRODUCTION IN AFRICA (THOUSAND TONNES LIVE WEIGHT)

Source: Compiled from FAO Fish Stat, 2020

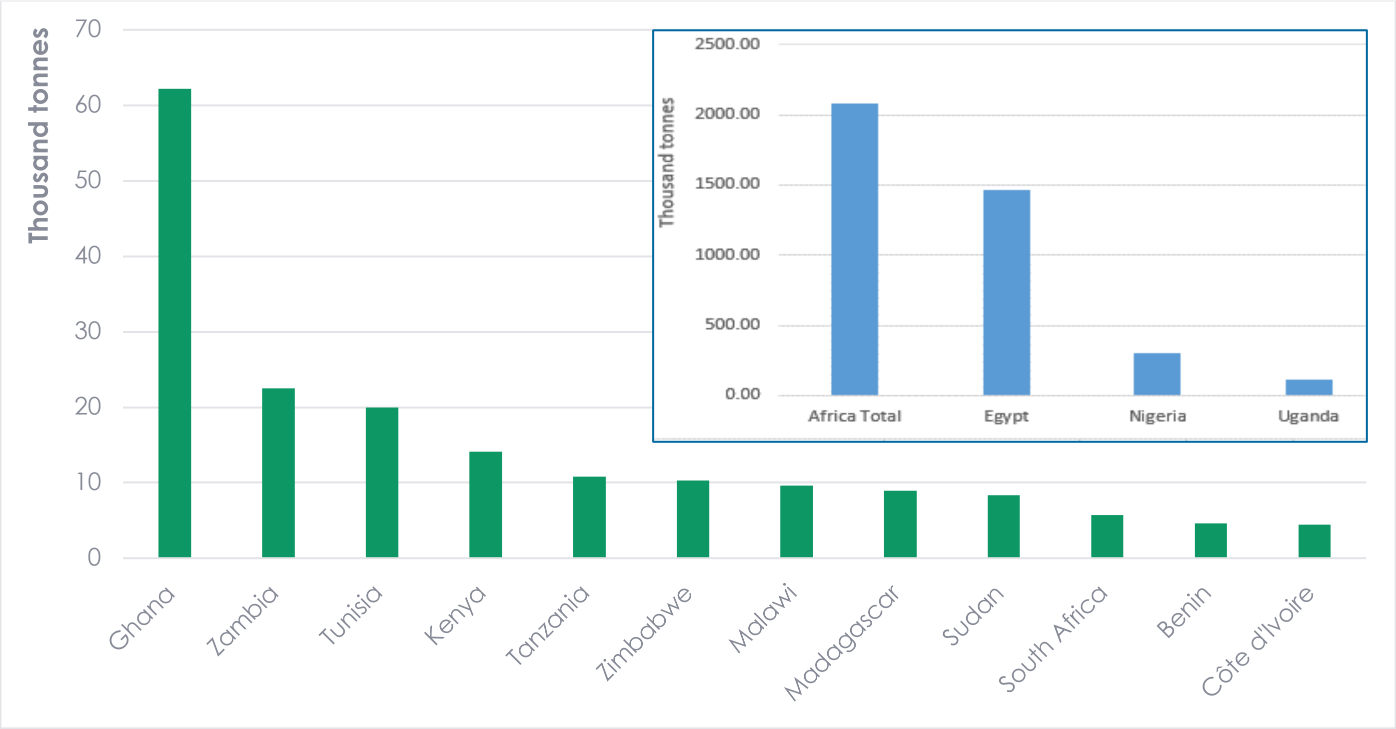

FIGURE 5: AQUACULTURE PRODUCTION PER COUNTRY IN AFRICA (AVERAGE 2016-2018) (THOUSAND TONNES LIVE WEIGHT)

Source: Compiled from FAO Fish Stat, 2020

In the Eastern Africa region, fish is produced in Burundi, Ethiopia, Kenya, Rwanda, Uganda and Tanzania through freshwater inland and marine capture fisheries and aquaculture. The inland capture fishery sectors provide most of the sub-region's fishery production. However, fish catches from wild sources have been declining, due to climate change, overfishing, habitat destruction, invasion of non-native species, poor governance, as well as illegal, unreported and unregulated fishing (Obiero et al., 2019). Aquaculture in the East African region focuses mainly on production of Nile Tilapia and the African Catfish, and is dominated by Uganda, where an average of 111 000 tonnes per annum were produced from 2016 to 2018. During this same period, Kenya, in second place, produced an average of 14 000 tonnes, down from the 18 0000 to 24 000 ton levels seen between 2011 and 2015 under the Economic Stimulus Programme (2009-2013). In Burundi, Ethiopia and Tanzania, aquaculture contributes less than 10% to total fish production (Obiero, et al., 2019).

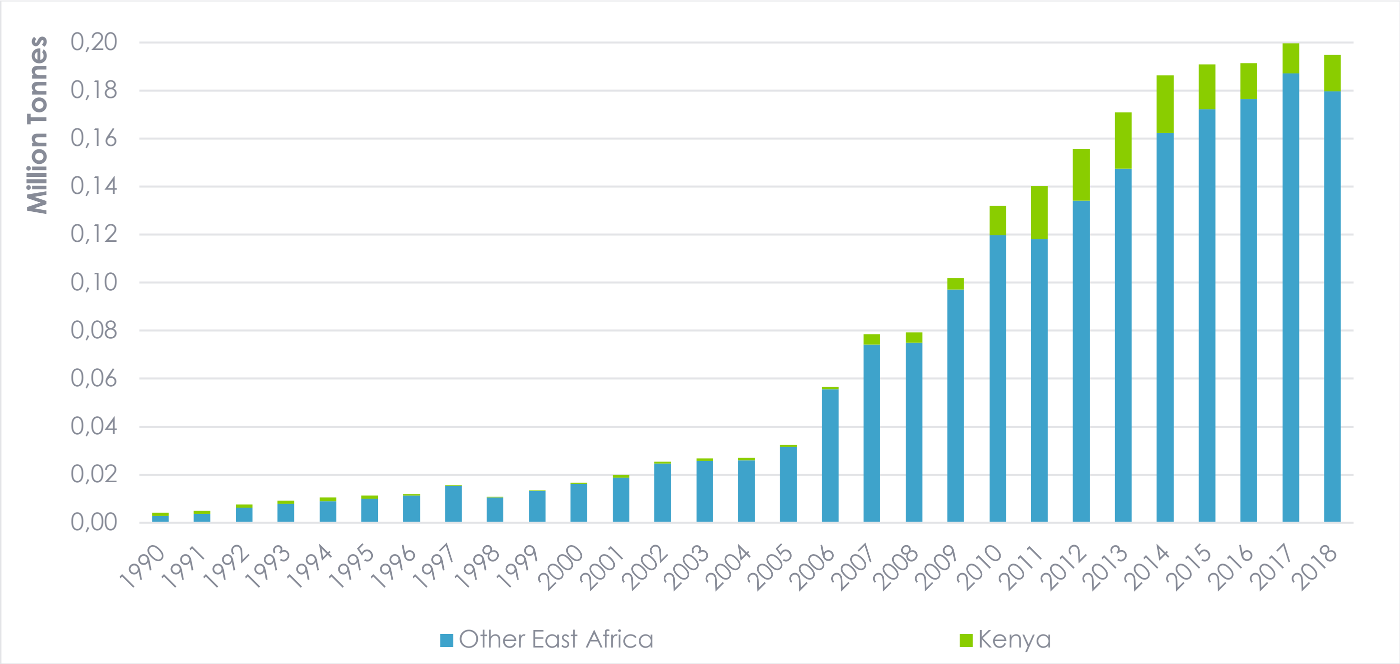

FIGURE 6: AQUACULTURE PRODUCTION IN EAST AFRICA (THOUSAND TONNES LIVE WEIGHT)

SOURCE: COMPILED FROM FAO FISH STAT, 2020

Per capita consumption of fish in Eastern Africa is low at 5.3 kg, compared to Southern Africa (8.9 kg), the whole of Africa (10.1 kg) and the global average (19.8 kg). From Figure 7, it is clear that as a source of protein, fish is more important in Tanzania and Uganda and increasingly so in Rwanda. In fact, the percentage share of fish in animal protein intake in Burundi, Rwanda, Tanzania, and Uganda is higher than the world average, signifying the crucial role that fish plays in food security in parts of Eastern Africa. This is also true for a number of other African countries, and while Africa has lower per capita fish consumption than the world average, it has a higher proportion of fish to total animal protein intake. Fish represents about 19% of total animal protein intake in Africa and this can be higher than 50% in selected African countries, in particular in West Africa (FAO, 2018).

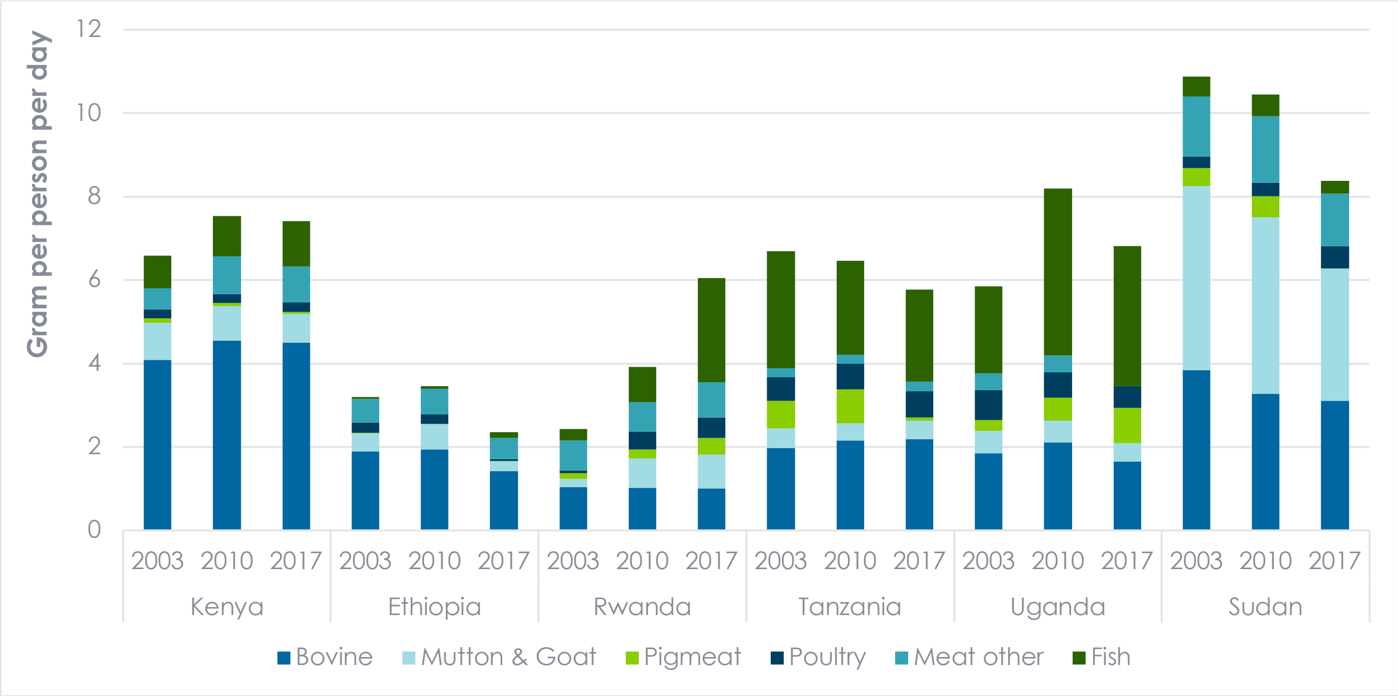

FIGURE 7: PROTEIN FROM MEAT AND FISH (PER CAPITA / DAY)

Source: Compiled from FAO Fish Stat, 2020

East African fish exports exceed imports in value but not in volume. Premium products are exported to high income countries in the EU and the Far and Middle East, while lower quality frozen Tilapia, Mackerels, Sardines, Prawns and Salmon are imported. Frozen Tilapia imported from China has dominated whole and filleted fish imports, while high quality Nile Perch captured in Lake Victoria by Uganda, Tanzania and Kenya dominates freshwater fish exports.

Obiero et al. (2019) found that fish trade in Eastern Africa has resulted in increased availability of fish to consumers because of improved logistics and market distribution systems, coupled with expanding aquaculture production and technological innovations. With improved logistics, wholesalers and retailers are able to source fish from all over the world, especially from China, to bridge the growing demand for fish in the region, and reduce dependence on fluctuating supply from capture fisheries and aquaculture. Fish traders in the region increasingly rely on imported frozen fish, due to its ease of availability, steady supply and price.

According to the FAO's Agricultural Outlook, 2018-2027, fish consumption is anticipated to increase in all continents except in Africa as population growth will outpace production growth. The 2018 report estimates that in order to satisfy the growing demand, Africa is expected to become further dependent on fish imports for human consumption. The decline in per capita fish consumption in Africa, with the subsequent reduction in the intake of fish proteins and micronutrients, can impact food security and countries' ability to meet malnutrition targets (FAO, 2018).

2.3. Domestic market overview

The oceans and fisheries sector plays an important role in the Kenyan economy. It provides food, employment and incomes to a large population, and earns the country an estimated KES 5 billion ($45m) annually in foreign exchange. Kenya's annual fish production is approximately 150 000 metric tons (MT) (Fisheries Annual Statistical Bulletin, 2016; FAO Fishstat, 2020), valued at approximately KES 39.2 billion at ex-vessel (farm-gate) price. The return from foreign fishing vessels is approximately KES 290 million annually (National Oceans and Fisheries Policy, 2018) and according to this policy, these earnings are expected to increase if the underutilised areas such as fishing in the Exclusive Economic Zone (EEZ) can increase.

The sector supports some two million fishers, traders, processors, input suppliers, merchants of fishing accessories and providers of related services directly and indirectly (CISP and KENWEB (2018) cited in KEMFSED, 2019). Therefore, the contribution of the fisheries sector to the national economy is much larger than just the primary production value and further encompasses linkages with other subsectors like feed manufacturing, which uses fish by-products as raw materials.

2.3.1. Supply and demand

According to the Kenya National Bureau of Statistics (KNBS), Kenya recorded an increase of 11.32% in earnings from the fisheries sector, with total fish output increasing from 135,100 tonnes in 2017 to 146,687 tonnes in 2018 (KNBS, 2020). In 2019 however the decline that has been evident since around 2014 continued, with 2019 freshwater fish output dropping to 120 873 tonnes, of which 18 542 tonnes came from aquaculture. Marine fish output in 2019 was 25,670 tonnes. The country has a reported annual deficit of 365,000 tonnes of fish against an estimated annual demand of 500,000 tonnes (KNBS, 2019). Historically however local consumption has rarely breached the 200.000 tonnes level.

Kenya has maintained a positive trade balance for fish over the years. However, the past decade has seen a significant increase in import value, along with a substantial decline in exports, to the extent that the trade balance turned negative in 2016, before recovering somewhat in 2019 and 2020. Exports comprise higher value products and are predominantly destined for Europe, but typically consist of captured species and have therefore declined in line with total fish capture. Conversely, imports comprise mainly Tilapia and have been increasing to aid in fulfilling domestic demand.

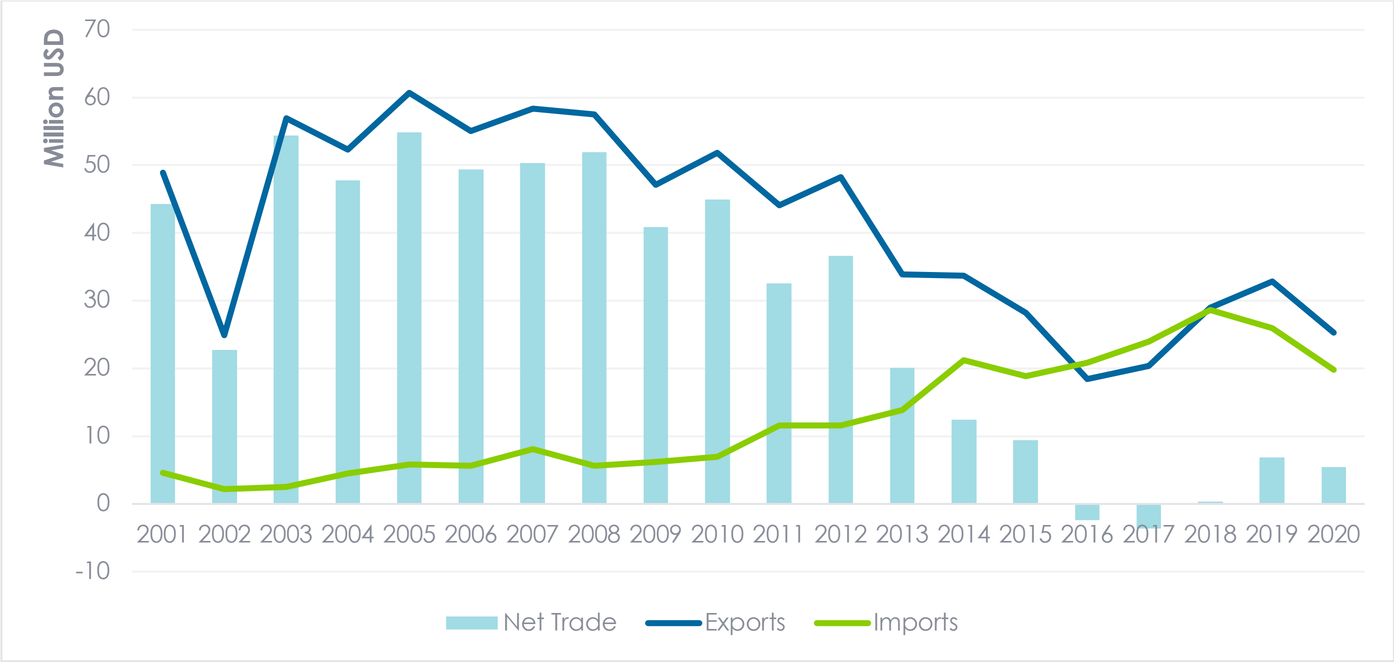

Figure 8: Kenya's net trade of fish

Source: ITC Trademap, 2021

Kenya imports Tilapia and Mackerel from China, which are cheaper than domestically farmed or capture fish, and account for 70-80 percent of the imports. Chinese fish imports come at very low prices mainly because of their efficient aquaculture system, which is also highly subsidized, up to 40% (IFAD, 2016)), often smaller sizes of fish, and locally perceived to be of lower quality. Mackerel is a popular species in Kenya because of its smaller size, which enables local fishmongers to cut it up and sell smaller portions at affordable prices. This is unlike the case of large fish, which are often sold whole, and hence less popular among low-income households.

The main Kenyan exports are Lobsters, Octopus, Tuna and Nile Perch. The most valuable Nile Perch product is the swim bladder (known as maw). A single Nile Perch swim bladder is more valuable than fillet from the whole fish. Some fishermen have been focusing on obtaining the swim bladders and throwing away the rest of the fish. However, to ensure that all the fish harvested gets into the food chain, there is a requirement that fish is landed whole at the lake beaches.

Per capita consumption of fish in Kenya is 4 kg/year, which is very low compared to the African and global averages, estimated at 10 and 20 kg/year, respectively. The main factors contributing to Kenya's low per capita consumption is the county's inability to satisfy demand, coupled with high prices for high quality export products. One of the objectives of the ESP was to create awareness of fish as a source of food and livelihoods, particularly among communities where fish is not part of their diet. Fish is a critical source of affordable animal protein, and its consumption has increased due to the health-conscious behaviour of individuals and households as well as initiatives such as the Eat More Fish Campaign, which was launched by the President of Kenya in November 2018. This was spearheaded by the State Department of Fisheries that sought to increase dietary intake of fish among Kenyans. The projects were successful in this regard and demand for fish grew, but supply was not sustained after the collapse of the ESP.

Projected growth in both income levels and the size of the population points to ample additional demand over the coming decade (Figure 9). This rapid growth in fish consumption is expected to lead to substantial market opportunities, but in order to meet this demand, domestic production will need to expand from around 15 000 tonnes to 150 000 tonnes in ten years' time. In the absence of such expansion, half of the fish consumed in Kenya by 2028 could be imported, at a cost of more than US$ 70 million per annum.

Sustainable resource management will undoubtedly have a role to play in safeguarding volumes currently obtained from captured fisheries, but given the finite nature of the resource, as well as the challenges that have led to declining volumes since 2014, the bulk of additional growth would likely need to come from aquaculture.

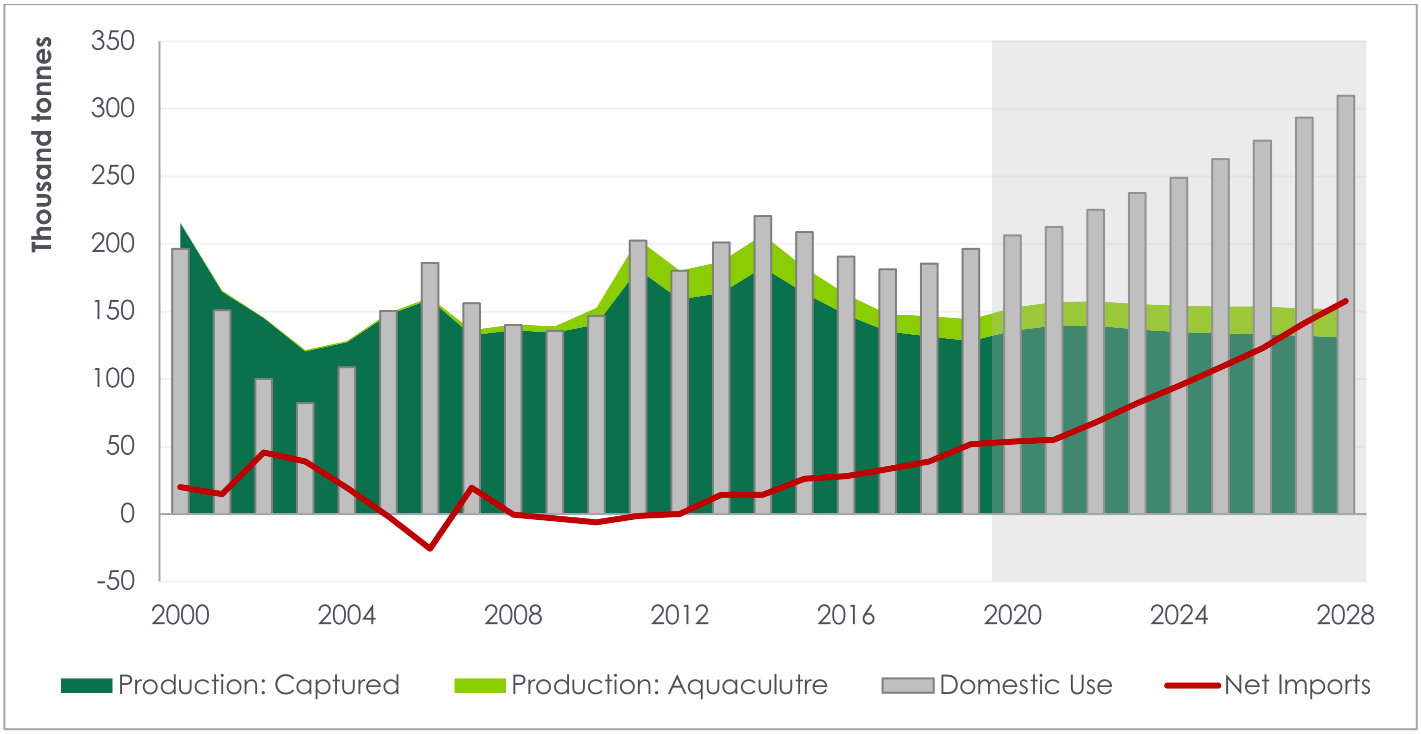

FIGURE 9: FISH PRODUCTION, CONSUMPTION AND TRADE IN KENYA: 2000-2028

Source: FAO Fishstat, ITC Trademap & BFAP Kenya multi-market partial equilibrium model, 2021

2.3.2. Spatial context of fisheries resources

The nature and composition of Kenya's fisheries resources (Figure 10) implies natural concentration around major water bodies. Capture fisheries are found in the coastal and marine waters of the Indian Ocean as well as the inland fishery waters (lakes, rivers and dams). Aquaculture is more broadly practised across the country, on land and in water bodies. Kenya is also endowed with many rivers found in high and low altitude areas. The lakes, dams and rivers also support recreational fishing (State Department for Fisheries, Aquaculture and the Blue Economy, 2018).

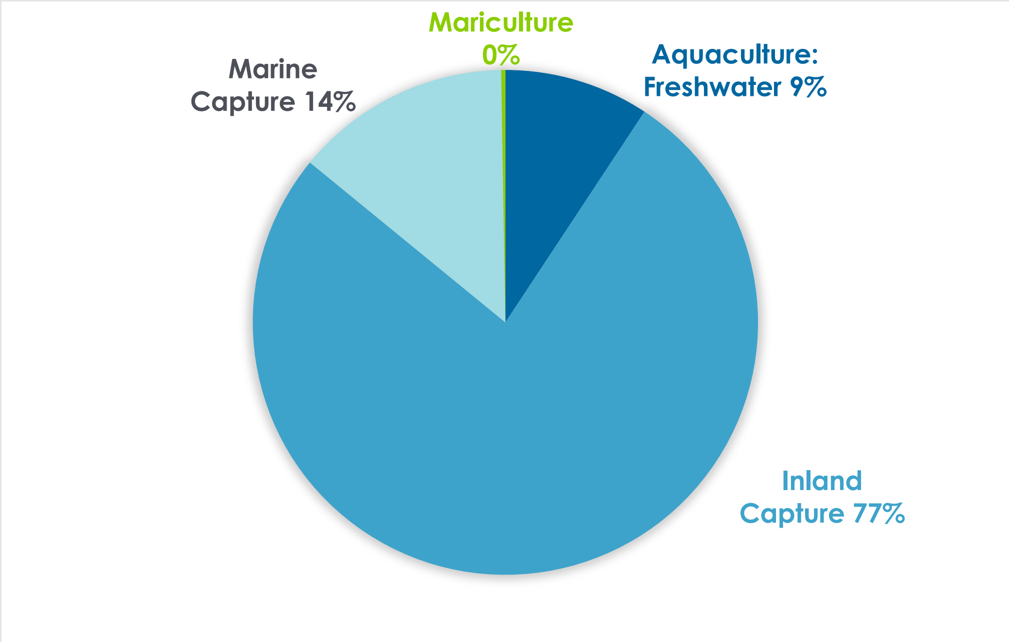

FIGURE 10: LOCAL FISH SOURCES: AVERAGE 2016-2018

Source: FAO Fishstat, 2021

Inland water fishing is done mainly in Lakes Victoria, Turkana, Baringo, Naivasha, Jipe and Chala as well as Tana River dams. Lake Victoria is shared among Kenya, Uganda and Tanzania, with Kenya having sovereignty over 6% of the lake. The lake has several specifies of fish, with the main commercial species being *Rastrineobola* ("Omena"), Nile Perch ("Mbuta"), Nile Tilapia ("Ngege") and *Haplochromis* ("Fulu"). Lake Victoria has historically been the main freshwater fish source, but its output has been declining in the recent past.

Marine fishing is found in the coastal waters, the territorial waters and the Exclusive Economic Zone (EEZ) of the Indian Ocean. Kenya has a coastline of 640 km on the Western Indian Ocean, as well as 200 nautical miles of Exclusive Economic Zone (EEZ) under its jurisdiction. Kenya has a large exclusive fishing zone with potential to produce 300,000 tonnes of fish annually estimated at about KES 75 billion. However, this opportunity is considerably under-utilized due to the lack of appropriate deep sea fishing gear and vessels, limiting Kenyan fishermen to mainly operate within five nautical miles from the shores. As a result, Kenya's marine resources are largely being exploited by foreign fishing vessels and illegal fishermen with advanced gear (Business Daily, 2018).

Capture fisheries in the marine waters is also often for subsistence purposes, undertaken by artisanal fishers in the shallow waters and within the reef using small non-mechanized fishing crafts. According to KEMFSED (2019), it is estimated that about 80% of the total marine products come from coastal waters and reefs, while the remaining 20% is from offshore fishing. Artisanal fishing is characterized by small crafts propelled by sail, outboard motors and paddles. Hence, it is mainly restricted to reefs, estuaries and lagoons and near-shore waters, which have a large variety of fish species, including many small and pelagic species (e.g. tuna, mackerels and demersal finfish) and invertebrate fisheries (e.g. prawns, lobster and octopus).

Obwanga et. al. (2020) noted that historically, the Kenyan aquaculture sector has followed three phases: introductory phase (1920-1950), donor and government support phase (1960-2000), and the private sector–led phase (2010-2020). Aquaculture was first practised in the country in the 1920s by the colonialists, initially for sport fishing and later evolved to fish farming in static water ponds. The trout fish hatchery was established in Kiganjo in 1948 to serve the cold water fishery and recreational industry. Warm water fish farming was later introduced in Sagana and a hatchery established to produce quality brood stock for farmers and to build their capacity in aquaculture (National Oceans and Fisheries Policy, 2018).

The donor and government supported phase started in the 1960s when fish farming was popularised by the government through the "Eat More Fish" campaign. The objective of the government and donors was to improve food security and job creation and alleviate poverty in rural areas through aquaculture. However, in spite of policy, technical and financial support through initiatives like the Farm Africa's Aqua Shops Project, funded by DFID and the Gatsby Foundation, through Msingi East Africa, the subsector remained largely subsistence oriented until 2009, when the government introduced the Economic Stimulus Project-Fish Farming Enterprise Productivity Program (ESP-FFEPP), which was intended to transform aquaculture into a commercial venture. This Programme provided farmers with fish inputs free of charge (labour for pond construction, fingerlings and feeds), capacity enhancement programmes and extension services to interested farmers.

During the ESP-FFEPP, a mapping of areas suitable for aquaculture was done based on water availability, climatic conditions, soil type, topography, land use and access to inputs and markets (Figure 11). As a result, some 9.58m ha were identified as areas of high suitability, 40.56m with medium suitability and 3.24m ha with low suitability (mainly in the arid and semi-arid (ASAL) regions) (Ogello and Munguti, 2016).

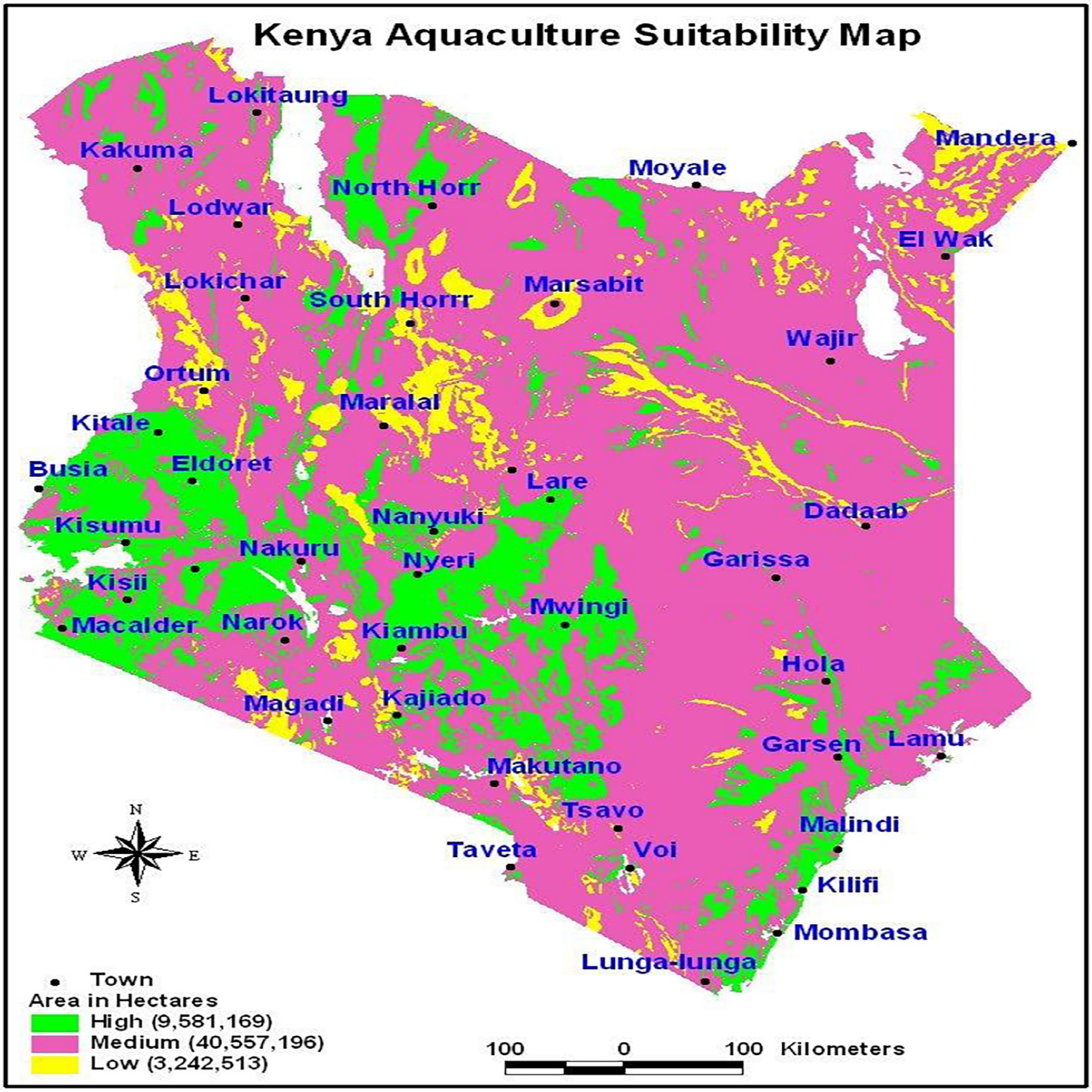

Figure 11: Areas suitable for freshwater aquaculture in Kenya: green: highly suitability; pink: medium suitability; and, yellow: low suitability.

Source: Ogello and Munguti, 2016.

The result of the ESP was an immediate increase in the number of farmers engaged in fish farming, and land under aquaculture increased from 722 ha in 2008 to 2,076 ha in 2013, while production levels increased from 4 452 tonnes (in 2008) to 23 500 tonnes by 2013 (Farm Africa, 2016). Statistics indicate that more than 60 000 ponds were constructed under the programme but the number of functional ponds and production have decreased over time, reducing from 69 194 in 2013 to 60 277 in 2015, while the area declined from 2 105 ha in 2013 to 1 873 ha in 2015 and production declined from 24 096 tonnes in 2014 to 18 656 tonnes in 2015 and further to 14 952 tonnes in 2016 (Obwanga et al, 2017). By 2015, the distribution of aquaculture activities across 38 counties showed a high concentration in a number of counties and low concentration in others (Figure 12). Nearly 21% of constructed ponds were in Kakamega (8 640 ponds) and Bungoma (3 972) counties, while 14 counties had fewer than a thousand ponds.

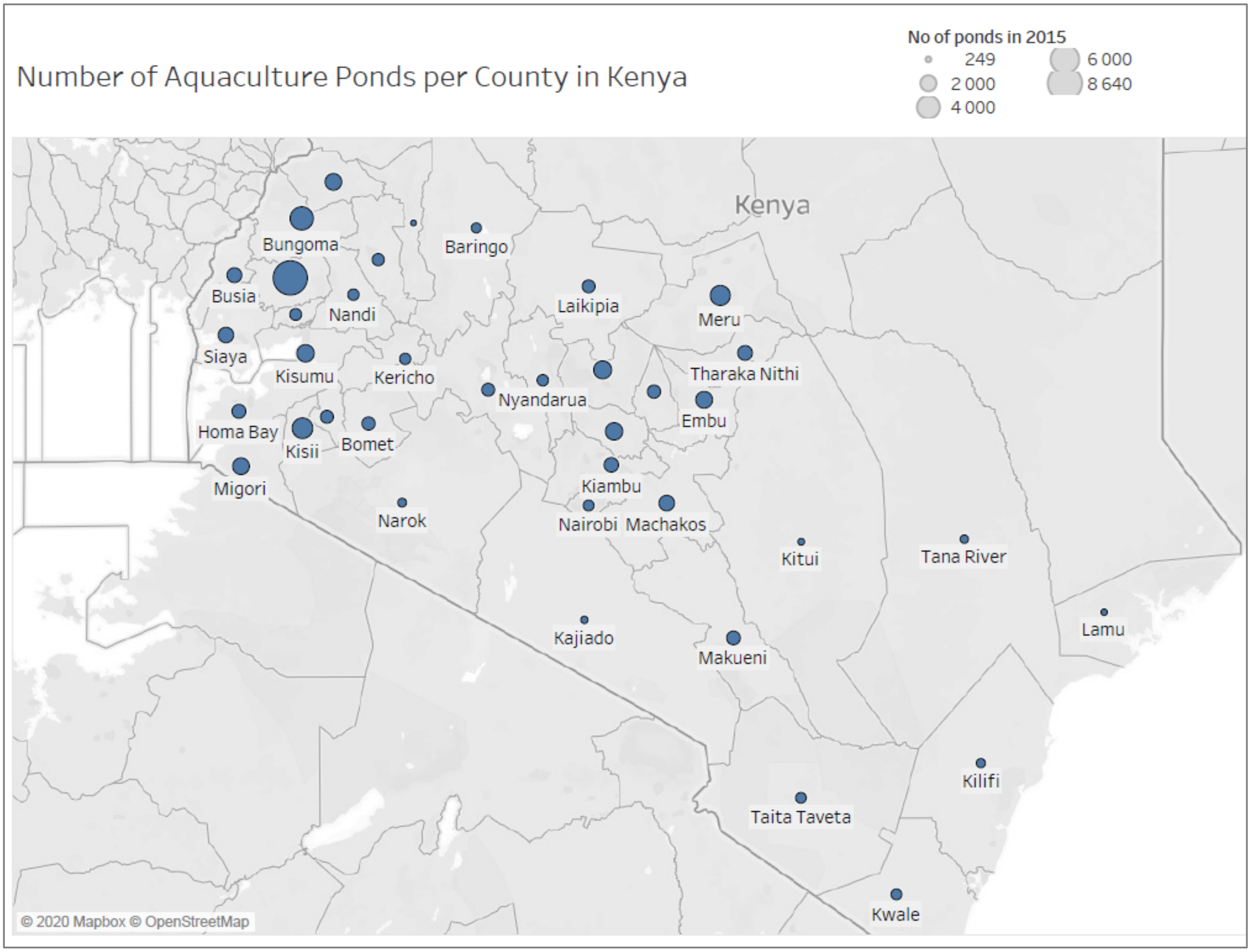

FIGURE 12: DISTRIBUTION OF PONDS IN 2015

Source: Adapted from Table 1 in Opiyo et al., (2018).

According to Obwanga et. al. (2020), the private sector–led phase only really took root following a study conducted in 2011 to explore business opportunities for Dutch companies to support Kenya's aquaculture sector. The study confirmed the potential for aquaculture in Kenya and attracted some Dutch-supported initiatives including FoodTechAfrica (FTA) (a public–private initiative partially funded by the Dutch Government), the Kenya Market-Led Aquaculture Programme (KMAP) (funded by the Dutch Embassy in Nairobi and led by Farm Africa), and Jambo Fish Kenya Ltd (a public–private initiative established in 2010 in Kiambu to produce catfish fingerlings in ponds and recirculating aquaculture systems and table-sized catfish for the urban market. This latter initiative later changed its name to Jambo Fish Western (K) Ltd and relocated to near Mumias, Western Kenya, in 2013. During this phase, the government played a role in creating a conducive business environment and the sub-sector benefitted from several strategies including a business approach to aquaculture, better access to knowledge, technology, fingerlings and commercial feed, introduction of intensive farming systems (e.g. RAS and cage farming), and large capital ventures and partnerships of foreign investors with local entrepreneurs.

Kenya's population is expected to reach 67 million by 2030, which means that the country would need around 270 000 tonnes of fish to maintain its per capita fish consumption at the level of the early 2010s (i.e. 4 kg/year). Even if Kenya can stabilise its wild fish production at the 2017 level (i.e. 120 000 tonnes), farmed fish production in the country would need to reach 150 000 tonnes in 2030 to satisfy the increased demand for fish (FAO, 2019). Given the country's current production levels, the aquaculture sector would therefore need to grow considerably over the next 10 years.

2.3.3. Policy framework

The governance of the oceans and fisheries sector in Kenya falls under several national institutions. Policies instruments include legal notices, regulations and Acts of Parliament which provide regulations and set up and empower institutions to implement them. The Constitution of Kenya (2010) ushered in a devolved structure of governance, with the national government's role being policy-making, regulation, capacity building, and research, while the county governments are envisaged to play the primary on-the-ground role of implementing policies and delivering services. Hence, most of the functions in the sector are devolved to the county level, but there are concurrent functions that are the shared responsibility of both levels of the government.

The value and strategic role of the ocean and fisheries sector is recognized through various government documents and plans. For instance, the Third Medium-Term Plan (2018-2022) identifies the agriculture, livestock, and fisheries sector as a priority, and highlights the importance of the country's marine resources and fisheries for local employment, income generation, and livelihoods of coastal communities. In addition, the Government's Big Four Agenda recognizes the importance of this sector and it seeks to leverage emerging opportunities in the Blue Economy. Kenya is keen in promoting sustainable blue economic development, and in November 2018 it hosted the Global Conference on Sustainable Blue Economy, with the main theme delivering on the UN's 2030 Agenda for Sustainable Development through a transition to a Blue Economy that is inclusive, sustainable and prosperous. Kenya committed to adopt appropriate policies, strategies and mechanisms to harness the blue economy that will create job opportunities, ensure responsible fishing, ensure safety and security on the high seas, and tackle waste management and plastic pollution.

The 2016 Fisheries Management and Development Act highlighted key regulatory and policy changes that are meant to harness the fisheries potential and protect the country's fish stocks. This is achieved through establishing and enforcing fishing measures and regulations for more effective management of the resources. The Act established several entities under the State Department for Fisheries, Aquaculture and the Blue Economy (SDFA&BE), with specific mandates to undertake functions in the fisheries sector. These entities include:

- **Kenya Fisheries Service:** responsible for the conservation, management and development of Kenya's fisheries resources, development of standards and guidelines, monitoring implementation of policies as well as providing education, awareness and support for conservation and sustainable use, among others

- **Kenya Fisheries Advisory Council:** to advise the national government on fisheries policy related aspects, allocation and access to fisheries resources and intergovernmental agreements, etc.
- **Fish Levy Trust Fund:** mandated to provide supplementary funding of activities geared towards management, development and capacity building, and awards and urgent mitigation to ensure sustainability of fisheries resource
- **Kenya Fish Marketing Authority:** mandated to market fish and fisheries products from Kenya enforce national fisheries trade laws and international fisheries related trade rules, and ensure that Kenyan fishery products enjoy market access at local, national, regional and international levels, etc.
- **Fisheries Research and Development Fund:** to provide resources to institutions that carry out research and development activities in the sector.

In addition, the Kenya Marine and Fisheries Research Institute (KMFRI) was established in 1979 as a State Corporation with a mandate to undertake research in marine and freshwater fisheries, aquaculture, environmental and ecological studies, and marine research including chemical and physical oceanography.

The 2016 Act allowed for the establishment of laws under the Beach Management Units **(**BMUs). These are associations of fisher folk, fish traders, boat owners, fish processors and other stakeholders whose livelihoods depend on fisheries activities. They are a component of fisheries co-management where resources are shared between the government and different user groups. They allow for organized and structured community participation in fisheries management. In their areas of jurisdiction, BMUs impose levies and charges, ensure protection of vulnerable groups especially women, youth and persons with disabilities, and monitor the utilization of beach resources and funds collected from beach users. However major reform is needed in the operations of BMUs since most of them have become moribund and in some cases, they are involved in perpetuating illegalities such as the use of prohibited fishing gear especially in Nile Perch fishing in Lake Victoria (KMFRI, 2018).

The State Department for Fisheries, Aquaculture and the Blue Economy is in the process of finalizing a revised National Oceans and Fisheries Policy. The first edition of a comprehensive fisheries policy was developed in 2008 but the enactment of the Constitution of Kenya 2010 introduced new institutional arrangements for the management and development of fisheries resources in the country, and this necessitated a review of the policy. The new constitutional dispensation calls for a more coordinated approach between two levels of government in sharing of resources and responsibilities, while tackling issues nationally, regionally and internationally.

The Government of Kenya is partnering with development partners to support the sector. For instance, the World Bank is funding the Kenya Marine Fisheries and Socio-Economic Development Project (KEMFSED) to the tune of USD 100 million. The project's development objective is to improve management of priority fisheries and mariculture and increase access to complementary livelihood activities in coastal communities. Another initiative, the Aquaculture Business Development Programme (ABDP), supported by the International Fund for Agricultural Development (IFAD), aims to enable existing and potential aquaculture producers to benefit from fish production in an economically and environmentally sustainable manner and promote local income-generating businesses that provide support services to the aquaculture sector. The proposed approach blends public and private sector investments in the aquaculture value chain with community-wide initiatives that promote good nutrition and food security[6].

A summary of the set of policies governing the fisheries sector is presented in Table 2.

TABLE 2: SUMMARY OF THE ACTS AND POLICIES GOVERNING THE FISHERIES SECTOR

Year enforced	Policy (Acts/ regulations/ institutions/ plans)	Verification and intension
1990	The Coast Development Authority Act Chapter 449	The Act provided for the establishment of the Coast Development Authority of Kenya. This institution is mandated to co-ordinate the implementation of development projects in whole of the Kenyan Coast and the exclusive economic zone and for related purposes. Lead to the Integrated Fish Resources Development Project implemented through public-private partnership to ensure sustainability of fisheries activities among other projects that seeks to preserve the coastal eco-system.
2005 and 2016	Fisheries Management Plan for Lake Victoria (2005-2008) Fisheries Management for Lake Victoria Plan (2016 – 2020)	Address challenges of Lake Victoria by introducing user rights in management of the Lake; introduction of a domesticated Fishing Craft Management System (FCMS) for Lake Victoria waters; introduction of fisheries and aquaculture incubation enterprises; demand-driven research; use of Information Technology to manage fisheries resources and regular economic evaluation of fisheries resources.
2009 and 2015	Nile Perch Fishery Management Plan 2009-2014 (NPFMP1) Nile Perch Fishery Management Plan 2015-2019 (NPFMP2)	To rebuild the biomass of the Nile Perch stock to the level that will sustain catches above 300, 000 tonnes per annum; to increase wealth generated by Nile Perch fishing and related activities by at least 10% through improved regulation of fishing activities and enhanced value addition in the artisanal and industrial post-harvest sector; and, to improve wealth sharing to the benefit of local communities.
2010	Prawn Fishery Management Plan (PFMP, 2010)	The aim is to ensure creation of employment, wealth, national revenues and foreign exchange earnings, fish products and protection of the prawn fishery and habitat in the long term.
2008 and 2018	National Oceans and Fisheries Policy 2018	The overall objective of the National Oceans and Fisheries policy is to: enhance the fisheries sector's contribution to wealth creation, increased employment for youth and women, food security, and revenue generation through effective private, public and community partnerships.
2013	Small and Medium Pelagic Fishery Strategy (2013)	To ensure compliance of fisheries management measures to prevent habitat destruction and over-exploitation of small and medium pelagic species to improve ecosystem integrity and socioeconomic development among fisher communities.

[6] https://www.ifad.org/en/web/operations/-/project/2000001132

2013	Tuna Fisheries Development and Management Strategy (2013 – 2018)	To transit tuna fisheries from artisanal-based fisheries to modern commercially oriented coastal and oceanic fisheries and accelerate economic growth of the marine fisheries with direct positive impacts to employment, wealth creation, improved incomes and foreign exchange earnings.
2013	Integrated Coastal Zone Management (ICZM) Policy 2013	To promote integrated planning and coordination of coastal development across the various sectors; promote sustainable economic development to secure livelihoods of coastal communities; conserve the coastal and marine resources and environment for sustainable development; manage environmental risks associated with changes in shoreline and climate; develop capacity in research and education; enhance stakeholder awareness and participation in sustainable resource management; and, establish effective institutional and legal frameworks for implementation of the ICZM policy.
2015	The Fertilizers and Animal Foodstuffs (Amendment) Act 2015	This Act amended the principal Act, Fertilizers and Animal Foodstuffs Act 2007 by providing for the establishment of an institution with functions and powers to be known as the Fertilizer and Animal Foodstuffs Board of Kenya. Act regulates the production importation, manufacturing, marketing and distribution of livestock (fish) feeds
2016	The Fisheries Management and Development Act 2016	To govern the conservation, management and development of fisheries sector in Kenya to guide sustainable utilization of fishery resources
2016	Beach Management Units	Beach Management Units to be established by the county governments to ensure structured community participation in fisheries management and ensure efficient supervision of conservation efforts by county governments.
2016	Malindi-Ungwana Bay Fishery Co-Management Area Plan (MUBF-CMP) (2016 – 2021)	The Plan provides a framework for addressing the challenges and threats facing the coastal and marine fisheries, specifically within the Malindi-Ungwana fishery.

Kenya is currently developing a new Blue Economy policy that is enteded to guide and boost sustainable utilisation of the country's marine and freshwater resources.

2.3.4. Joint programmes and initiatives to promote aquaculture in Kenya

Economic Stimulus Programme (ESP) and the Aquaculture Business Development Programme (ABDP)

Under the Economic Stimulus Programme (ESP) of 2009–2013, smallholder aquaculture fish production was promoted through targeted support for input supply, fish production, post-harvest management and related activities.

During this period, the ESP was able to achieve a rapid expansion in the productive infrastructure in the subsector, including the central region which had little history of fish production or consumption. However, a study by Obwanga et. al. (2020) found that while the ESP support benefited farmers engaged in pond farming and medium-scale commercialized tanks, this support did not necessarily correlate with the level of commercialization. The aquaculture value chain in Kenya is still not well articulated, with clear weaknesses in the availability of good quality fish feed and fingerlings, technical services, processing and value addition enterprises, and market access.

In 2016, the government sought International Fund for Agricultural Development (IFAD) assistance for support in designing and funding a project that supports smallholder aquaculture fish production. IFAD commissioned a team to review issues emanating from the ESP, the rural communities and other public and private sector stakeholders, and to generate an appropriate package of capacity-building and investment measures to accelerate and consolidate the expansion of aquaculture production.

The report recommended the establishment of the Aquaculture Business Development Programme (ABDP), whose aim was to increase incomes, food security and the nutritional status of poor rural households involved in aquaculture ventures. The Programme set out to support the small-scale fish production base for existing and new producers, with priority for women and youth, by promoting viable enterprises for production and value-addition.

The total program cost is estimated at $143.3 million consisting of an IFAD loan of $67.9 million, Government of Kenya funding of $31.4 million, beneficiary contributions (43.6 million) and an FAO grant of $400 000.

The ABDP was set up to target counties with a high concentration of aquaculture activity, high production, and existing sectoral infrastructure. The Programme was initiated in six counties in the first year and then expanded to reach a maximum of fifteen by the third year of implementation.

The Pragramme was organised into two components - smallholder aquaculture development and aquaculture value chain development.

I. **Smallholder aquaculture development:** To be done by providing technical advice to smallholder producers on site selection for ponds, construction, seed selection, stocking density, pond fertilization, fish health, record keeping, savings, financial literacy, business management skills, collective marketing, quality standards, food safety, value addition and processing. Also included in this component is provision of small grants for the purchase of production inputs as required by the producers.
II. **Aquaculture value chain development:** This will be implemented by providing contracts to Public Private Producer Partnerships aimed at creating an environment composed of small and medium-sized aquaculture producers and entrepreneurs.

Women, youth, landless and other disadvantaged groups were the target beneficiaries. Target direct beneficiaries were 35 500 households while indirect beneficiaries will include public and private sector entities that will be capacitated by the program as a way of reaching the rural target and other members of the community not directly involved in the program. Among the public entities include schools that will benefit from nutrition and other initiatives.

Several stakeholders are involved in the programme, with the main ones being Government Ministries and departments (Kenya Fisheries Service, Veterinary department, National Environmental Management Authority, Water Resource Authority), County Governments, Research Institutions (Kenya Marine and Fisheries Research Institute & Universities), Training Institutions (Sagana Aquaculture Centre & Ramogi Institute of Advanced Technology), the FAO, smallholder aquaculture farmers and private enterprises including banking institutions and insurance companies.

The ABDP has supported the development of the Aquaculture Blue Book, which is a consolidated database of all the enterprises and value chain actors involved in fish farming in the 15 program counties (ABDP, 2021). This involved conducting an assessment of aquaculture value chain players in the 15 counties, which focused on six categories of aquaculture value chain players, namely farmers, feed producers, processors, traders, input suppliers and organizations. Key findings from the assessment include: (i)The predominant production system recorded was earthen fishponds accounting for 72.3% of the total ponds; (ii) Fifty-six (56) percent of fish farmers practiced subsistence fish farming, 31% semi-commercial and 13% commercial fish farming; (iii) Eighty-one (81) percent of farmers reared Nile Tilapia while Catfish, Ornamental, Common Carp and Rainbow Trout farmers accounted for 18%, 0.4%, 0.29% and 0.1%, respectively; (iv) 66% of traders sourced fish from lakes, 19% from aquaculture facilities, 5% from rivers and 2% from dams, while 8% imported fish from other countries; (v) Most fish processors (53%) were in the cottage industry (processing an average of 0-300 kg per month), while 39% and 9% processed 301-1000 kg and above 1000 Kg of fish per month.

Farm Africa in Kenya

Farm Africa has been promoting fish farming in ponds and working directly with fish farmers, suppliers and traders to improve the production and marketing of farmed fish since 2011, initially setting up a network of aqua shops to help disseminate high quality equipment and inputs; promoting the adoption of aquaculture best practices for improved production, as well as strengthening market systems and the policy environment so that farmers can turn their ponds into profitable enterprises.

The programmes implemented by Farm Africa include:

- **Aqua shops.** The project was implemented from 2011-2015 with the aim of empowering aqua shop owners to grow in their fish business linked to farmers in the ground. It was also handling farmers' extension and technological support and customers of input who socked their inputs. The programme lasted for 5 years and was funded by Ford Foundation.
- **Kenya Market-Led Aquaculture Programme (KMAP).** It started in in 2016 and ended in December, 2019 and worked with fish value chain actors including the farmers, input dealers and traders. It was funded by Kingdom of Netherlands and worked across the entire fish farming value chains in 14 counties. The project was of the idea that if more investment is made in fish farming, then the farmers will be enabled to lower their costs of production and increase their profitability.
- **Strengthening the Aquaculture Ecosystem.** It helps beneficiaries by empowering them through technical capacity enhancement through sustainable and environmental management and policy lobbying through aquaculture associations. They act as facilitators in ensuring that the implementers are well equipped to perform their objectives.

There are laws and regulations both at national and county level but enforcement is not effective. Fish is not given priority as compared to crops. It's only in Kakamega County where an input subsidy was implemented with the government up to 50% of input costs.

The Kenya Climate Smart Project

The Kenya Climate-Smart Agriculture Project (KCSAP) is a Government of Kenya/World Bank-supported project under the State Department for Crops Development in the Ministry of Agriculture, Livestock, Fisheries and Cooperatives. Munguti et al (2020) indicated that component 2 of the project aims at strengthening technical and institutional capacity within the National Agricultural Research System (NARS) to deliver Climate Smart Agriculture (CSA) Technologies, Innovations, and Management Practices (TIMPs) and develop sustainable seed, breeding stock and fingerlings delivery systems in Kenya. For the aquaculture value chain, the project aims to upscale appropriate climate smart aquaculture TIMPs developed by the NARS, mainly the Kenya Marine and Fisheries Research Institute (KMFRI) and national universities. These include technologies that improve production efficiencies at the hatchery or farm level, while mitigating environmental impact; support/enhance land-based recirculation production systems; advance novel feed ingredients; and reduce carbon footprint through improved energy efficiency or regeneration. To support efforts in the aquaculture value chain under this project, experts prepared a *Training of Trainers' Manual for Climate Smart Aquaculture Practices* (Munguti et al (2020).

County level initiatives

Several counties have invested in programs and initiatives to support the development of aquaculture. Some of these efforts are county-specific, while others are in collaboration with projects that are funded by the Government and donors, such as ABDP, KSCAP and the Kenya Devolution Support Program (KDSP).

For instance, Busia County is undertaking the following:

i) Construction of a modern fish market and a fish processing plant through KDSP
ii) Reviving fish hatcheries in the county (i.e Wakhungu, Okerebwa and Butula) and a fish feed plant through KCSAP

The Kiambu county government has been collaborating with the Kenya Women's Trust to support intensive fish production in dams and cages. It has also set up bulking and collection centres and provided fish farmers with freezers.

While some counties are making progress toward strengthening aquaculture, others like Nyeri and Meru have been struggling to keep their fish factories in operation. Currently, the two counties are seeking investors to run the factories, which were built under the ESP but have been lying idle[7]. In Nyeri, the Wamagana processing factory has the capacity to process 21,000 metric tonnes of fish daily but it has been operating below capacity for nearly six years. Despite the County's investment of KES 50 million in rehabilitating over 225 fish ponds, restocking dams and purchasing dam liners and fish feeds, production has not grown fast enough to keep the factory running. As in the case of the Kanyakine processing plant in Meru, all the fish that is currently produced is consumed locally and does not need to pass through the factory. Fortunately, both Meru and Nyeri are ABDP target counties and hopefully the program's component on smallholder aquaculture development will increase production to levels that can support the factories. In addition, it's community nutrition

[7] https://www.standardmedia.co.ke/adblock?u=https://www.standardmedia.co.ke/national/article/2001412802/counties-out-to-lease-factories-as-clients-keep-off-pond-fish

initiatives are expected to encourage inclusion of fish in diets and hence boost fish consumption and production.

The Aquaculture Academy

As outlined in various government strategies and policies, aquaculture is increasingly playing an important role in national fish supply and hence contributing to food security, poverty reduction and employment creation. With over eight years of experience in the aquaculture sector, FoodTechAfrica, a 21-member consortium of companies from the Netherlands and Kenya identified lack of skilled human capital as a key constraint in promoting profitable and sustainable aquaculture in East Africa. Hence, the consortium founded the Aquaculture Academy, aimed at unlocking the potential of aquaculture in Kenya. According to FoodTech Africa[8], the Academy will train and build 'aquapreneurs', who will be able to run a sustainable and profitable business, and also inspire others to become fish farmers and hence contribute to growth, profitability and the competitiveness of the fishing sector. The farmers will receive practical, accessible and business-oriented training programs covering all essential aspects of aquaculture production. It is expected that through the Academy, farmers, investors and stakeholders will benefit from knowledge transfer in terms of innovations, practical skills, customized and localized solutions as well as global best practices.

3. VALUE CHAIN ANALYSIS: ASESSMENT OF CURRENT STATE

Figure 13 presents a schematic of Kenya's fish value chain. In 2018 an estimated 90% of Kenya's local fish production came from wild capture, with 95% of the 90% coming from fresh water capture, mainly in Lake Victoria. The aquaculture industry contributed an estimated 15 000 MT (10%) in 2018, produced in ponds and in cages in the Lakes.

Processing of fish and fish products in Kenya is limited as most produce goes directly for human consumption. Tilapia, the main and most popular species, is marketed, sold and consumed as a whole fish with limited to no processing besides gutting and icing. The wild caught Nile Perch is filleted and largely exported with limited by-products, while the wild caught Omena (*Rastrineobola argenteato*, aka Silver Cyprinid or Lake Victoria sardine) is consumed fresh or dried and it is estimated that about 20% enters the animal feed market, but mainly only once the quality has deteriorated to such an extent that it is no longer suitable for human consumption, and as a result the fish meal quality is low.

[8] https://foodtechafrica.com/aquacultureacademy/

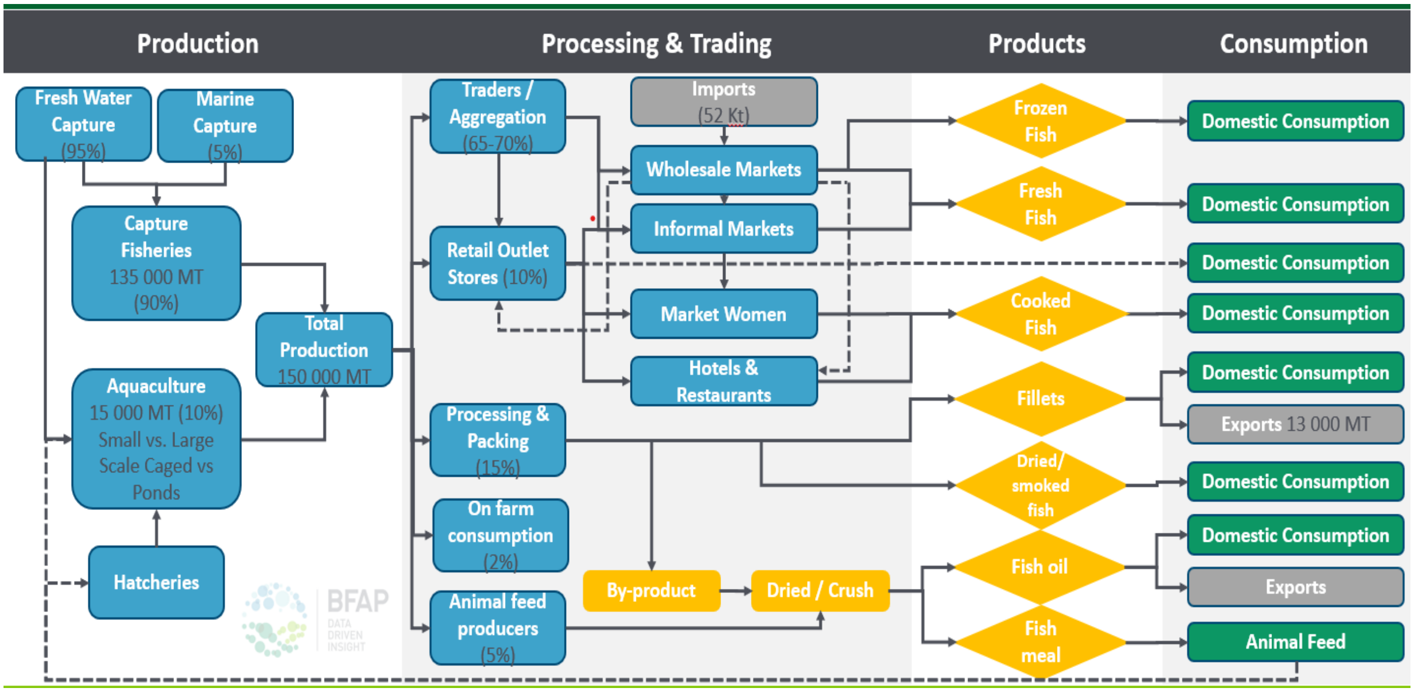

FIGURE 13: KENYA FISH VALUE CHAIN WITH 2018 VOLUMES AND PERCENTAGE SHARES

Source: PPVC Value Chain Analysis

Small scale extensive aquaculture farmers mainly produce African catfish, which is more resilient and has more processing potential, but fish are mainly sold in local markets and volumes are rarely sufficient to warrant investment in further processing. The above mentioned ABDP focusses on catfish production support and informing and shaping Kenyan consumer perceptions regarding catfish meat but compared to Central and West African countries, catfish is not popular in Kenya (yet) and the local market is largely centred around Tilapia. For this reason this assessment also focussed on Tilapia.

Owing to greater growth potential, the deep dive analysis is focussed on aquaculture, as opposed to fisheries as a whole. Figure 14 presents the product flow through the value chain, with a focus on aquaculture in the primary production node.

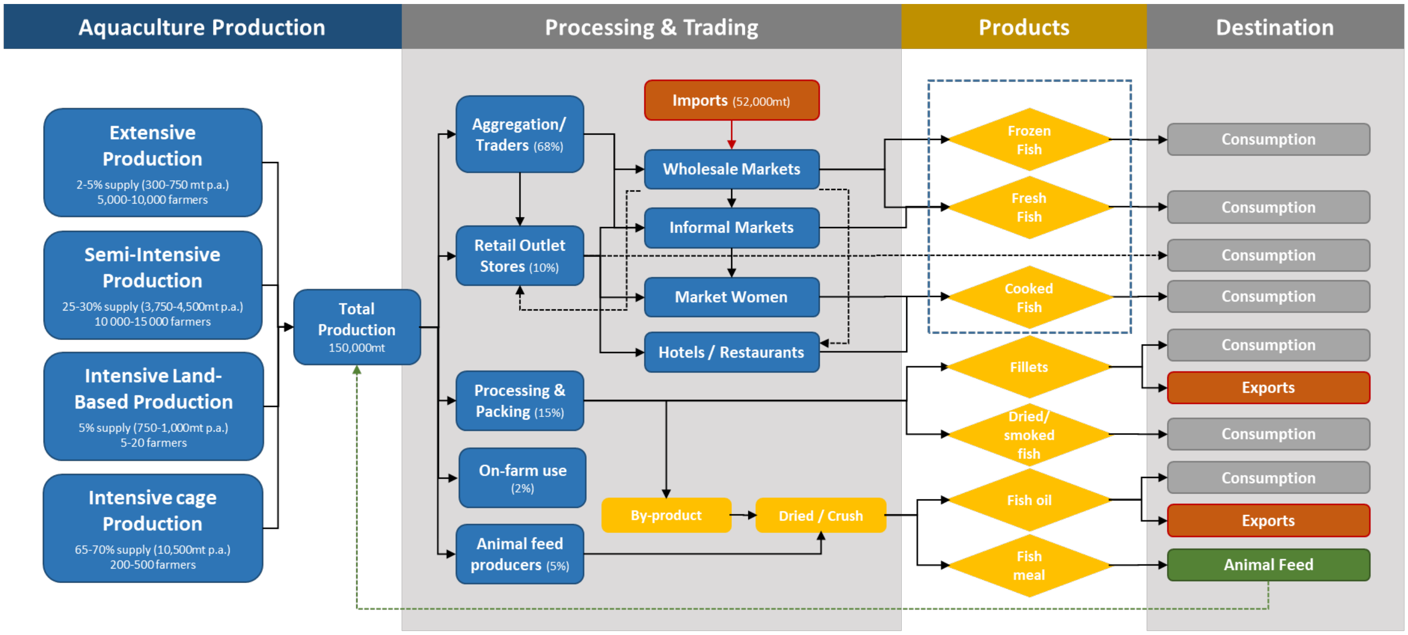

FIGURE 14: KENYA FISH VALUE CHAIN WITH 2018 VOLUMES AND PERCENTAGE SHARES

Source: PPVC Value Chain Analysis

3.1. Aquaculture production systems

Aquaculture production systems used in Kenya can be categorized into extensive, semi-intensive and intensive, with the intensive further divided into land-based aerated ponds or recirculated aquaculture systems and lake-based cage systems. More than 90% of farmers practise semi-intensive fish farming, while the intensive system is practised by only 3% due to the high cost of electricity and non-availability of affordable quality feeds (Opiyo et al., 2018). Across 15 counties where ABDP is being implemented, most farmers practise subsistence fish farming (56%), followed by semi commercial (31%) and commercial fish farming (13%). The leading counties in commercialization of aquaculture are Homa Bay County, Kakamega and Kisii (ABDP, 2021).

In a recent study, Obwanga et. al. (2020) grouped farmers into nine commercialization categories, emphasising that farmers in the aquaculture sector cannot be treated as a homogeneous group. The categories are based on the three main production systems (ponds, tanks and cages) and varying levels of commercialization, defined as low, medium and high. Key observations made in this study include:

(i) Pond farming is the least commercialized system, though it has received the largest subsidy allocation in the past;

(ii) Cage farming in Lake Victoria is growing fast and is expected to contribute significantly to aquaculture supply in the future. However, to ensure sustainability, regulations and planning to monitor environmental impacts are urgently needed;

(iii) tank farming is highly commercialized and its success depends on appropriate technology, which is expensive and so accessible only to a few fish farmers. These systems are mainly used for breeding and hatcheries for sale of fry and fingerlings.

For the purpose of this report, aquaculture production has been grouped into four main freshwater aquaculture production systems, as per Figure 14 and summarised below.

3.1.1. Extensive production

Extensive production occurs in the available water bodies such as dams and ponds. In this system, fish are reared in a natural environment and the only input added is organic or chemical fertiliser to improve the growth of water algae. The species mainly cultured in this system are African catfish and to a lesser extent Nile Tilapia. Many of the dams and ponds were stocked with fingerlings through the ESP as a way of sensitising communities on aquaculture as an alternative farming activity. Fish have also been stocked to prevent breeding of mosquitoes in ponds and dams constructed for watering livestock. Such dams are mainly found in Central and Rift Valley regions. While Ngugi et al. (2007) estimated that these farmers account for 10% of farmed fish in Kenya, current estimates are at less than 5%. Production is consumed mainly on-farm, while the rest is sold locally to neighbours, schools and the community.

3.1.2. Semi-intensive production

Semi-intensive production is the most common aquaculture system in Kenya with a low-feed input system, where farmers use earthen, liner or concrete ponds and fish are reared in a natural environment. However, chemical and organic fertilizers are added in the ponds to enhance growth of natural feed. Supplementary feeding is done to enhance productivity, with feeds coming from on-farm feed formulation or purchased from cottage industries and large manufacturers/importers of fish feed. Production from this system is in the range of 1,000-2,500 kg per ha per year (Ngugi et al., 2007). The most enabling factor for pond farming is its orientation towards food security and nutrition. However, farmers with medium and low commercialised ponds tend to use cheap, poor quality homemade fish feed and feed meant for other livestock (e.g. poultry and pigs). This results in feed use inefficiency, which compromises growth of the fish and leads to waste of feed, nutritional diseases in fish and pollution of the water in the ponds, increasing food safety risks (Opiyo et. al., 2018; Obwanga et al., 2020)

3.1.3. Intensive production

The intensive production systems yield substantially more fish per unit area. Good water aeration enables higher stocking densities and intensive feeding occurs using high quality, commercial feed rations. Intensive systems typically take three forms: raceways, recirculating aquaculture systems and cage fishing.

Raceways
Raceways is a system that is mainly used to produce rainbow trout (*Oncorhynchus mykiss*) in Central Kenya, where there are 6 commercial trout farms. The system requires high quality feed that is expensive and hence only a few farmers have invested in it. By 2014, the State Department of

Fisheries (SDF) reported that the production of trout from the raceways was 241 MT valued at U$ 1,430,000 (SDF, 2014). It is estimated that production in this system is between 10,000 and 80,000 kg per ha per year (FAO, 2016).

Recirculating aquaculture systems

This is mainly tank-based and is used to produce Nile Tilapia (*Oreochromis niloticus*) and African catfish (*Clarias gariepinus*). Fish are reared in tanks indoors or under greenhouses with plastic or netting cover. Improved technology is used to maintain water quality using pumps. In 2020 there were at least 8 farms operating recirculating systems in the form of hatcheries and grow-out farms in Kenya. Fish are grown under controlled conditions and at a high stocking density ranging between 5 and 20 fish per m^3. The production is estimated at 200 tonnes per ha per year (SDF, 2016). However, the system is not widely adopted due to the high initial capital investment required for tanks and greenhouses, and the high cost of electricity required in running the system (Opiyo et al., 2018). The system is mainly found in the peri-urban areas of Nairobi, Kiambu, Nyeri, Meru, Kisumu, Machakos, Kilifi, Homa Bay, Kakamega and Busia (SDF, 2016). Despite the initial high investment require, the tank system is associated with higher gross margins and incomes where higher prices can be earned for high quality larger fish.

Cage fishing

Cage fishing has been practised in Lake Victoria since 2013, where production is solely dependent on purchased and not natural feeds. It is currently practised in five riparian counties (Migori, Siaya, Homa Bay, Busia and Kisumu), with the highest numbers of cages found in Siaya county. It is estimated that Lake Victoria currently has about 4 000 cages of varying sizes, but mainly of 2 by 2 by 2 square metres, under 60 different owners. Most of the cages are individually owned (62%), while the rest are owned by groups (Njiru and Aura, 2019). Cage farming has a huge potential to increase aquaculture production and support economic growth around the Lake Victoria region. This is because, compared to conventional fishing, it has a very high stocking density, requires relatively less investment per unit area[9], uses existing water bodies hence reducing water demands on land, and is less affected by drought. Furthermore, there is ease of relocation of cages from one site to another as well as ease of accessibility for operational practices, such as feeding and cleaning the nets (Njiru and Aura, 2019). Despite its potential, it has been noted that there is a need for a balance between cage culture and capture fisheries to ensure sustainability of the fisheries resources in the lake. In the long-run, cage farming may lead to environmental challenges such as the discharge of nutrients from the fish feed and excretions, which could lead to changes in the ecosystem, hence, there needs to be proper regulations on cage farming and enforcement of the existing guidelines by the East African Community (Njiru and Aura, 2019). Indeed, Musinguzi et al. (2019) noted that, "cage aquaculture is expanding on African inland waters and has potential to close the fish supply deficit in the region and provide other social benefits such as employment and income. However, if not appropriately guided and regulated, caged aquaculture could become unsustainable, causing conflicts with other water uses, environmental degradation and economic losses to aquaculture enterprises".

Obwanga et. al. (2020) indicated that prospects for cage farming are hampered by the fact that it is growing faster than the governance mechanisms are evolving due to uncoordinated policies and regulations and confusion over management and regulation after devolution. Another key

[9] According to Njiru and Aura (2019), the cost of starting up a cage industry (i.e. cage material, feeds, fingerlings, security, a boat for accessing the cages and labour) varies greatly from US$4,300 to US$590,000, since the cages, source of materials and size of the operations vary significantly.

problem is lack of financial and human resources. To deal with these challenges, Njiru et al. (2018) suggested the need for an effective policy framework and mapping of the lake, based on resource use, and to ensure better management and regulation of breeding areas and cages and to reduce conflict among users, fish farmers and fishermen.

Cage fish farming has been going on in Homa Bay County since 2015 when aquaculture farmers engaged with the Beach Management Units to be allowed to farm in Lake Victoria waters. This was a new technology by then and farmers started their activities in the Lake in the absence of general guidelines as conceived by the Fisheries Management and Development Act, 2016. The Act provides for the conservation, management and development of fisheries and other aquatic resources to enhance the livelihoods of communities that depend on the water body and the resources around it. In general, anyone intending to get involved in cage fish farming must obtain a National Environmental Management Authority (NEMA) certificate, cage fish farming permit from the Kenya Fisheries Service and concession/allotment letter from the Ministry of Lands and Physical Planning specifying the area for placing the cages. The Fisheries Management and Development Act 2016 had not come in to force by the time farmers in Homa Bay engaged in cage farming, but it clearly stated that before a permit is provided, there is need for an environmental and social impact assessment. Even after the commencement of the Act in September 2016, the fisheries department has had the dilemma of whether it is worth burdening an individual farmer who has few cages with the acquisition of all the requisite documents.

A permit is required in order for the farmers to be allocated suitable areas to place their cages and suitability maps are required in order to locate where the cages are placed to avoid overfishing in the Lake. Any party interested in cage fish farming is required to seek a permit from the National Government. County governments do not issue permits, but their role is to monitor the aquaculture activities within their jurisdiction.

Due to a failure in following guidelines, some fish cages have been placed in the lake against maritime laws and they pose an environmental hazard to marine life. Fish cages are interfering with the lake's ecosystem because they have been placed without any environmental impact assessment. Many aquaculture farmers in Homa Bay and Siaya counties who engage in cage fishing have contributed to the dwindling of fish stocks. An increase in cages has led to a reduction in capture fish because they are encroaching the breeding areas. Some of the cages are also placed on the transport routes. It is feared that continuous unregulated placement of cages in the lake may soon lead to the introduction of non-approved species of fish.

Similar to the approach at the coastal waters of Kenya, the lake requires zoning to identify suitable areas for cage placement. As additional infrastructure is being developed for transport within and around the lake (railway port, ferry routes, hospitality and recreation), zones will have to be marked for large-scale (aquaculture), small scale or individual farmers (aquaculture) and fishing (capture).

To conclude the description of production systems and provide an indication of further value addition and marketing practices, Table 3 provides a summary and description of the current state of the four main systems in Kenya, based on the findings of the value chain deep dive.

TABLE 3: SUMMARY OF KENYA AQUACULTURE PRODUCTION SYSTEM CHARACTERISTICS

	Extensive	Semi intensive	Intensive land based system	Intensive cage system
Description	Pond systems where inputs are limited to occasional introduction of fingerlings and occasional water fertilization or feeding with low cost products. Some communal ponds	70% pond and 30% cage system in lakes, where fish are grown at mid-level densities in monoculture or polyculture (Tilapia and catfish) on a batch/cycle basis	An aerated pond, flow through raceway or recirculating tank system (RAS) whereby fish are reared in high density. Some farms focusing exclusively on fry/fingerling production.	A floating cage frame and net moored in a larger water body and housing a relatively high density of fish. Monoculture, with multiple units housing different batches of fish.
Contribution to national aquaculture production	2-5%	25-30%	5%	65-70%
Production	300-750 MT/annum	3 750 – 4 500 MT/annum	750 – 1000 MT/annum	10 500 MT/ annum
Number of farmers	5 000 – 10 000 farmers	10 000 – 15 000 farmers	5-20 farms	200-500 farms
Species	30% Tilapia 70% catfish	70% Tilapia 30% catfish	80% Tilapia 20% trout Limited catfish	98-100% Tilapia 2% experimental Nile Perch and trout
Genetics	Fry collected from wild, some bought from hatchery Own stock breeding	Fry collected from wild or bought from hatchery	Batch stocking from high quality fingerlings purchased or self-spawned and raised for use and sale	Batch stocking of fingerlings purchased from a hatchery, self-spawned and raised or wild fingerlings collected
Feed use	Limited formulated feed used. Predominantly focused on biotic growth of zooplankton and algae, which may be stimulated by the addition of maize, chemical fertilizer or manure.	Systems typically rely on a combination of feed from their natural environment, as well as a supplementary feed source fed to the fish at relatively low rates	Exclusively high quality extruded pelleted feed	High quality extruded pelleted feed is used. Mainly imported with some locally produced.
Harvest	Monthly harvest of few bigger fish. Harvest as needed for personal use and the pond rolls on with fish not harvested. Occasionally supplemented with	A unit is typically harvested in a short space of time (few days). Cleaned and restocked.	Uniform sized fish harvested on a planned schedule matched with market demand.	Different units are usually in a rotational basis where harvest of a single unit is done over a few days at most.

	additional fingerlings.			
Processing	Gutting and scaling and occasional drying for household storage.	Gutting, scaling and occasional icing for transport.	Product processed, packaged and iced. Fingerlings/fry sampled, packaged in oxygen saturated tanks/bags for transport.	Variable degree of processing, from whole round fish, gutting and scaling, sorting different size classes and filleting.
Transport	90-95% used in walking distance. 5-10% moved fresh without ice to nearby settlements.	Packed in crates / cooler boxes. Picked up at farm gate by pickup or small truck.	Transported by truck with reefer unit to customer.	Collection by distributor in pickup/truck at farm gate and transported to informal/formal market. Trucks with reefer transport fish to more formal market sector, some to distribution hubs. Transport may be short distance to nearby informal settlements or longer distance to urban centres.
Market	Mainly household consumption. Excess sold to neighbours and nearby community and 5-10% in informal market place.	Dropped off by distributer to informal traders in small settlements/ open air markets.	Target the high end formal market of hotels & restaurants, possibly some formal shop retailers. Fingerlings/fry sold to semi and intensive fish farmers.	Informal traders buying from distributors and selling in town markets (cooked or uncooked). Fish retail outlets selling uncooked fish to end consumers. Hotels and restaurants buying from distributor or fish retail outlet. Hotels and restaurants will collect or have fish delivered by distributor/retail outlet. Occasional

				filleting or cutting fish into chunks before cooking.
Producer Price	Fish sold by piece, not by weight. Tilapia at an equivalent of KES 300/kg and catfish at KES 350/kg	Fish sold by piece, not by weight. Tilapia at an equivalent of KES 300/kg with catfish at KES 350/kg	Fish sold by weight. Tilapia at KES 500/kg whole KES 2000/kg filleted. Catfish at KES 500/kg whole, KES 1000/kg filleted. Trout at KES 1000/kg whole, KES 2000/kg filleted.	Whole round Tilapia at KES 270/kg, gutted and scaled at KES 300/kg, cooked fish sold per pieces at equivalent to KES 600/kg

3.2. Fish markets and prices

Large traders who purchase substantial volumes of fish mainly target large urban markets. Demand is higher than the traders can supply in cities and towns such as Kisumu, Nakuru, Nairobi, Eldoret and Mombasa, so bulk buyers are able to negotiate price discounts. They are in most cases interested in a steady supply of fish at prices that they are able to sustain (Obwanga et al., 2020). This arrangement largely favours farms who supply institutional clients interested in plate size fish, ideal for restaurants.

Farmers producing fish under the semi-intensive system sell fish at retail prices to household consumers who live within the local area. Small scale pond farmers can also sell small amounts of fish for an extended period until the whole stock is depleted. Small scale farmers in Western Kenya add value right after harvesting by deep frying, as a means of preservation, while also meeting the needs of customers in the highly populated urban areas. In highly intensive systems, there is a high cost of maintaining large volumes of mature fish, hence the tendency to dispose of a whole batch at once, sometimes at relatively lower prices. Farmers who sell an entire stock at once or sell high volumes at any one time, prefer to sell to wholesalers.

Prices of farmed and captured fish are determined at the source through agreements between buyers and sellers. At Lake Victoria, prices are negotiated based on subjective assessment by the trader or Industrial Fish Processor (IFP) agents, who also provide storage equipment for fishermen at the landing beaches. Nile Perch meant for processing must meet the processor's criteria such as size and freshness. The remainder of the fish is sold to other players in the chain such as wholesalers, retailers and even consumers. Processors, wholesale traders and transporters get supplies from the landing sites every morning. Some of these traders and processors own fishing gear and they employ fishermen who are paid daily wages.

For aquaculture, wholesale traders get information on specific harvesting days when fish farmers in a given area have agreed to sell off their fish. Harvesting is done in the evening and fish are put in refrigerators/coolers and then picked up by trucks mounted with cold storage equipment.

To obtain information on the nature of the fish markets and prices received, key stakeholders were interviewed in major fish markets and landing sites in Nairobi, Siaya, Kisumu and Homa Bay. These are the major points of sale.

3.2.1. Gikomba wholesale market in Nairobi

The Gikomba market in Nairobi is an open air, wholesale fish market that supplies Nairobi and the adjacent towns. There are four main fish species traded in this market: Tilapia, Nile Perch, catfish and mudfish - with Tilapia and Nile Perch the most commonly traded. Though the market is frequented by both retail traders and consumers, the price they face in the market is similar. However, there are retail traders who have established business relationships with wholesalers and are, therefore, able to purchase on credit. Procurement and sales practices as well as prices can differ across the major species.

Nile Perch

Nile Perch is captured in Lake Victoria in Kenya's main landing sites and also imported from Uganda and Tanzania. The buying and selling prices in 2020 were in the range of KES 220-250 per kg and KES 280-300, respectively. There is an increase in consumption of Nile Perch because it is easier to eat since it has fewer bones compared to Tilapia.

Tilapia

Tilapia is the most popular fish and is supplied from different sources. There are three categories available i.e. captured, farmed (caged or pond) and Chinese imports. Captured Tilapia is sourced from Lakes Naivasha and Victoria (both in Kenya and Uganda). Farmed Tilapia is either caged, pond produced or imported (Chinese). Pond fish is mostly procured from central Kenya, particularly Muranga County. Prices for the 3 categories are different and the fish can be distinguished by their physical characteristics and appearance, especially when still fresh. Caged Tilapia tends to be darker compared to captured. Traders also reported that fish from the various sources have different tastes e.g. capture and caged Tilapia from Lake Victoria do not taste the same – likely due to different feed sources.

Captured Tilapia is highly preferred but only affordable to higher income consumers, who acknowledge its quality compared to that from other sources. However, it is common for consumers to purchase caged fish at the same price as captured Tilapia from Lake Victoria. Prices for Tilapia from different sources are shown in Table 4.

TABLE 4: PRICES FOR TILAPIA BY SOURCE

Price	Captured (Lake Victoria)	Farmed, Caged (Lake Victoria)	Captured (Lake Naivasha)	Farmed (Pond)
Buying	KES 340/kg	KES 260/kg	KES 40-50 per piece (pricing is per piece)	KES 40-60 per piece (pricing is per piece)
Selling	KES 380/kg	KES 330/kg	KES 70-120	KES 50-80

Pond Tilapia and that captured from Lake Naivasha is often small in size, hence pricing is on a per piece basis, depending on the size. Larger sized fish are sold in Naivasha and Nakuru towns and the remaining transported to other towns. Cheaper, smaller Tilapia is commonly retailed in low income areas, where consumers are more concerned about accessing larger quantities at relatively lower prices.

Traders indicated that frozen Chinese Tilapia had brought stiff competition to pond fish, because of its very low prices. The Chinese imports are supplied in packages of 10 kg, with labels showing the range of fish sizes contained in each package. The table below lists the prices of Chinese fish in the Gikomba wholesale market in 2020. One trader explained that the normal practice is to include fish of a given range of size in one package up to the point where a weight of 10 kg is achieved. The first two package sizes are the most traded. The last package size of 700 grams and above sometimes contains fish of more than 1 kg a piece.

TABLE 5: PRICES OF FROZEN CHINESE TILAPIA

Approximated number of pieces	Weight range per piece for most fish in the package	Current buying price (KES)
28 to 33	200-300 grams	2100
24 to 26	300-400 grams	2200
22 to 20	300-500 grams	2300
16 to 18	400-600 grams	2500
	500-800 grams	2700
	600-800 grams	2750
6 to 7	700 and above	2750

Most of the wholesale traders sell a 10 kg package for a margin of between KES 200 and 250. Similar to pond Tilapia, consumers buy deep fried Chinese fish from retailers at a price of between KES 80 and 120 per piece for the small sizes of less than 400 grams. The companies importing Chinese fish supply wholesalers at the Nairobi market using their refrigerated trucks. The transportation of frozen fish from China is by sea to Mombasa port then by road to the depots in Nairobi, from where it is distributed to different regions in the country.

Catfish and mudfish

Catfish and mudfish are mainly sourced from Lake Victoria, Tana River and farms from central Kenya. Buying prices for farmed catfish tend to be lower (KES 200/kg) than for capture catfish (KES 270/kg). The buying price for both farmed and captured mudfish is similar, in the range of KES 300-350 per kg.

Dried and smoked fish

All capture fish species (Tilapia, Nile Perch, catfish and mudfish are sold in dried and smoked forms. Smoked fish is sourced from Uganda through the Kenya-Uganda border in Busia county. The fish is sold to retailers in various regions around Nairobi city.

3.2.2. Fish landing sites

The major fish landing sites for captured fish around Lake Victoria are Port Victoria (Busia County), Muhuru Bay (Migori County) and Mbita, Sindo and Nyandiwa (Homa Bay County). Wholesalers have their own agents at these landing sites who work hand in hand with the respective Beach Management Units to control how fish business occurs. Not all fishing areas have landing sites. Landing sites are equipped with facilities that enhance efficient trade such as cold storage and good roads that make them accessible for easy movement of trucks. A wholesaler normally orders a given quantity of fish and his consignment is weighed and labelled with his name and pick up point. The transportation trucks usually contain orders by several traders along the route from the landing sites to the final destination. The transporter receives payment for the service at the landing site, and hence transport costs are already included in the buying price. At the destination, the package owner weighs his fish to confirm the information that was communicated by the agent. Transportation of fish from Uganda is done by middlemen based on the Kenyan side of the border who pass fish through the border under inspection by Uganda Fisheries to the Busia County border market. It is eventually loaded to buses or trucks to Nairobi.

Wholesalers order fresh fish according to the needs of the retailers they serve. In the open air market, an allowance of about 10 to 15 kilograms is given to cater for other buyers/consumers beyond the retailers with orders. Besides buying expenses, traders incur other costs such as a mandatory charge of KES 100 per package and market charge per day of KES 100. Nairobi County is currently constructing a modern market that will provide facilities necessary for fish trading, including provision of clean water and cold storage equipment.

Interviews with wholesale traders and a representative of the Beach Management Unit at the Usenge Beach in Siaya County indicated that wholesale traders purchase fish mainly from other traders who are in direct contact with fishermen. There are middlemen, who are local fish maw agents who sell gutted Nile Perch to other traders after removing the maws.

As in Nairobi market, prices differ across species and product lines. The average buying price for gutted Nile Perch is KES 230 per kilogram, which is sold at KES 250 and KES 260 to local traders and wholesalers based in Nairobi, respectively. Tilapia is sold at KES 300 per kg regardless of whether it is farmed or captured. Besides fish purchases, the major cost drivers for these traders are transport and ice for preservation during transportation.

Nile Perch

In Siaya county, non-gutted Nile Perch fetches higher prices compared to gutted, depending on the size. In Mbita/Suba in Homa Bay County, gutting of fish prior to sale is prohibited because of pollution and wastage created by the fish maw trade. In both regions, pricing of Nile Perch differs according to size (Table 6), because the overall fish size determines the size of maw that is extracted The size of fish is determined by the size of the maws.

TABLE 6: NON-GUTTED NILE PERCH PRICES

Size range (grams)	Average price when weighed (KES)
Usenge Beach in Siaya County	
100 to 200	300
300 to 400	350
500 to 900	400
1000 to 1900	500 upwards

Homa Bay County	
Below 3 kg	150 to 200
Between 3 and 4 kg	300 to 450
Above 5 kg	500 and above

Trade in maws is large and growing, and it is reported that maws can fetch up to US $1000 per kg and the amount exported from Kenya, Tanzania and Uganda estimated to be worth US $86 million a year[10]. The extracted fish maws are sold to a local agent of a Chinese firm based in Kisumu, which is a lakeside city. The agent has networks in all the landing beaches around Lake Victoria. Prices of fish maws as at 11th October 2020 are presented in Table 7 and it is clear that maw prices are vastly higher than fish prices.

TABLE 7: FISH MAW PRICES

Size (grams)	Price in KES
5	1,000
18	4,600
35	5,300
50	6,500
70	7,300
100	9,500
150	11,800
200	14,300
400	19,300
600	22,000
1,000	27,000
1,500	34,000

Tilapia

At the Ogal Beach in Kisumu County, Tilapia is sold at KES 350/kg to traders. Captured Tilapia is much more expensive and fishermen do not allow it to be sold by weight. This is because capture fish has higher demand but it is lighter in weight compared to the cultured variety, and hence pricing is done per piece. The piece rate translates to an average of KES 450/kg.

Traders transport fish to Kisumu town for sale, while some is packed and transported to small towns around Kisumu. This beach has storage facilities mainly used by businesses that have invested in cage fish farming. Due to its close proximity to Kisumu city with high demand for fish, traders have no difficulty in selling their fish which is quickly purchased and taken to the urban centre.

Mbita/Suba in Homa Bay County is the main trading area for fish sourced from Rusinga, Mfangano and Takawiri islands. Production of captured fish in the Mbita Sub-County constitutes about 40% of total fish production. Price of Tilapia is KES 300/kg for both cultured and captured fish. Cold storage is available, including an ice making machine, which operates at lower capacity because of reduced demand.

[10] https://thefishsite.com/articles/uganda-signs-swim-bladder-deal-with-china

Important drivers of fish prices

Fish prices are mainly determined by seasonality of the production cycle and buyer type, for capture and farmed fish, respectively. Seasonality in captured fish is brought about by ocean currents, moon phases and the breeding cycle. These factors affect availability of fish in large water bodies, hence the supply fluctuates. Fishing of Omena (*Rastrienebola Argentea*) is done using artificial light used to attract insects at night. The effect of artificial light is diminished during full moon. Every year, fishing of Omena is always halted for a period of 2-3 months to allow for breeding, a situation that often results in a shortage that drives up prices.

Kenya relies on Tilapia imports from Uganda, Tanzania and China. Large volumes of captured Tilapia fish traded in Kenya is sourced from Port Victoria in Busia County of Western Kenya, and other fish landing areas, which are in close proximity to the Kenya-Uganda border. Fish landing sites such as Usenge Beach also get supplied with fish captured beyond the Kenya boundary, mainly from Uganda. Unlike Uganda, Tanzania has very strict regulations on importation of Nile Perch. Any production challenges experienced by fishermen in Uganda affect the supply of fish in Kenya. However, fish prices are also affected by other factors.

Local controls within the fish landing sites are created through deliberate association of fisher folks, wholesalers and transporters operating within a given area, who have set rules that seek to regulate the individuals doing business and the prices set for fish. These rules exist to protect the interests of the local groups by shutting out potential competition that may limit the rewards of their fish businesses. These controls have strong backing from Beach Management Units in their areas of jurisdiction.

3.3. Major inputs

Across the various aquaculture production systems, the major contributors to the cost of production is feed and fingerlings. In some systems, these are procured independently, while in others they are integrated into a single producer, but both have a significant influence on production cost and efficiency and are therefore critical to competitive aquaculture production.

3.3.1. Fish feed

The number of feed suppliers in Kenya has increased since 2009, following the ESP, and currently, there are 24 approved feed suppliers, of which six import feed. However, growth of the feed sector is hampered by weak regulation, which has resulted in poor quality feeds (Obwanga et. al, 2020). The main raw materials and ingredients used for fish feed processing are soybean meal, maize, sunflower, wheat bran, pollard, rice polish and imported fish meal protein (*Profish*) from Egypt. The leading fish feed producers are Sigma Feeds Ltd, Unga Feeds Ltd and Jewlet enterprises. Other providers of fish feeds are distributors of high-quality imported feeds such as Samaki Express E.A. Limited, who are well-known among most fingerling producers. Fish feeds from Unga Ltd are highly regarded for their quality, which also makes them pricey. Other established livestock feed processors acknowledge that products from Unga Feeds are of superior quality and since they are not able to match the quality, they use pricing as a leverage to market their products. Quality constraints amongst many of the domestic feed producers is also a reason frequently noted by producers for opting to rely on imported feed instead.

The cost of raw materials is a major cost component in the production of feeds, constituting up to 70% of the final cost paid by the farmers. Production and marketing costs account for the remaining 30%. In this regard, the high cost of major raw materials is a significant constraint to the development of a competitive animal feed industry in Kenya. The major challenges related to animal feed manufacture in Kenya include:

- High aflatoxin levels. Some feeds are rejected due to high aflatoxin levels that in some cases have exceeded 10 parts per billion
- Overreliance on imported raw materials since the country does not produce sufficient amounts of oil crops and maize.
- Low yields as a result of poor crop and soil management practices in the production of crops that are a source of raw materials for feed processing.
- Compromised quality of feeds by the emerging small enterprises that are engaged in local feed formulation. Feed mixing and formulation require proper machinery, which is lacking for most of the small enterprises. Small enterprises also make use of the most affordable and available raw materials and as a result some locally formulated feeds do not always provide the correct balanced diets for fish, resulting in nutritional deficiencies and poor growth.
- Low levels of crude protein in fish feed raw materials supplied to feed processors.

Kenya has a large deficit of raw materials for livestock feeds because especially maize competes with human food consumption. Uganda has gradually emerged as a more efficient producer in the dairy and poultry sector due to the availability of quality raw materials such as maize, sunflower cake and cotton seed cake. Among the East African countries, Kenya has the largest capacity to utilize maize bran, sunflower cake and cotton seed cake, which are available at a lower cost from Tanzania and Uganda. Tanzania and Uganda enjoy a more relaxed tax regime compared to Kenya, which further stimulates imports from these two countries.

Some raw materials are available locally in Kenya, though at a higher cost. However, the main protein sources, which include soybean meal, sunflower cake and cotton seed, are imported. The costs and sources of raw materials are as presented in Table 8 but can fluctuate considerably more than the range indicates.

TABLE 8: COSTS AND SOURCES OF RAW MATERIALS

Feed ingredient	Cost per kg (KES)	Origin
Maize	25-30	Local and imports from Uganda
Molasses	16-20	Local
Soybean meal	50-60	Zambia and Uganda
Sunflower cake	30-35	Tanzania

Wheat bran	20-25	
Wheat pollard	25-28	
Rice polish	16-20	
Cotton seed		Uganda
Imported fish meal (Profish)	85-90	Egypt (the product is zero rated)

3.3.2. Fingerling production

Fingerling production occurs in multiple hatcheries located in different parts of the county, with both government and private sector ownership. Most independent hatcheries are fairly large operations and distribute fingerlings widely. Production systems range from earthen and lined ponds to advanced recirculating air systems. Hatcheries require good management of brooding stock and often use imported feed to ensure optimal quality. Hatcheries typically sell mixed or mono sex fingerlings. Additional hormone treatments make monosex fingerlings more expensive to produce, but they also fetch a premium due to superior growth.

Fngerlings are fed and managed to a stage where they are ready to transfer to cages or ponds, with a full cycle of Tilapia fingerling production taking roughly two months to complete. Collection of fertilized eggs begins after 10 days for a period of not more than a month. The eggs are transferred to a hatchery for incubation under controlled environment where they take between 12 and 24 hours to hatch. The fry is transferred to separate tanks for feeding where they are treated with powder feeds mixed with sex reversal hormone (methyl testosterone) for a period between 21 and 28 days. This period is shorter (21 days) when the prevailing temperatures are higher than overall temperature in the region. The fry that are sold as mixed sex are not subjected to the hormone. Apart from feed and hormones, other major cost drivers in fingerling production include maintenance, labour and electricity.

While producers prefer larger fingerlings which have a greater chance of survival, limitations in availability often necessitate procurement of small pre-fingerlings, which affects growth performance and cycles. In order to aid in availability of hatcheries, government has also invested in breeding facilities, which can also be utilised for training purposes. Some of these investments include:

- ***National Aquaculture Research and Development Training Centre***: Situated in Sagana, the Centre is supplied by River Ragati and has a total of 170 operational ponds of different kinds: concrete, earthen and raised. There is also an installation for aquaponics demonstration. The centre engages in aquaculture training and capacity building and outreach activities, but serves three major functions:
  - Research (by the Kenya Marine and Fisheries Research Institute (KMFRI))
  - Production (by the State Department of Fisheries)
  - Training (by the State Department of Fisheries)

  Some of the outreach activities being undertaken by the centre include:

- Establishment, authentication and licencing of hatcheries, scouting for qualified and resourced individuals to operarate them.
    - Monitoring of quality seed production and certification to control quality in the sector.
    - Development of feed guidelines and standard operating procedures for seed production, feed and fish quality and new aquaculture regulations.
    - Training of farmers on aquaculture production
    - Development of value added aquaculture products. These are innovative products aimed at encouraging local consumption of fish.
    - Storage of fish seeds: KMFRI collects wild species of fish, which are reared as broods for reproduction.

- ***Lake Basin Development Authority:*** The Lake Basin Development Authority (LBDA) is a government agency under the Ministry of Regional and East African Community. Its mandate is to provide demand driven quality products and services through integrated planning and development to catalyse sustainable socio-economic development by promoting development resource based investment in the Lake Basin Region. With respect to fisheries, the facility is engaged in the following activities:
    - Production of Catfish and Tilapia fingerlings
    - Production of table size fish
    - Integrated training and technology transfer

  The farm aso undertakes capacity building for farmers through practical demonstrations before they receive their orders for fingerlings. A precondition for purchase of fingerlings from the Authority is that the buyer needs to disclose information on the size of the pond, intended stocking density and the location of the farm. The farmers are then advised regarding the number of fingerlings to purchase. As a centre for integrated technology transfer, LBDA conducts training for institutions and farmer groups supported by different organizations. Farm Africa is a major partner in facilitating the training of many farmers in Western and Nyanza Province. Training is offered at subsidized rates depending on the type group.

Overall, although there has been improvement in the production of fingerlings across the country, some challenges still remain, which include:

- Poor quality of fingerlings produced by emerging hatcheries around Lake Victoria, to meet the increasing demand from cage fish farmers. Most of these are unlicensed fingerling producers who double up as cage fish farmers, some of whom are selling premature fingerlings because of soaring demand by cage fish farmers. This happens because the enforcement of hatchery regulations is weak.
- Equipment required for establishing a hatchery is very expensive, since it is usually imported.
- Inputs and especially fish feeds are expensive, partly due to high taxation and the cost of importing most of the raw materials.
- The affordable commercial fish feeds in the market are not up to the required standards. Most farmers have to feed their fish for 9 months or longer instead of the normal 6 to 8 months.
- Uncertainty surrounding the increase in fish cages in Lake Victoria and the entire eco-system

4.1. Challenges in the aquaculture sector in Kenya

Overall, aquaculture production in Kenya faces a number of challenges, including high prices for commercial fish feeds, poor quality of feeds, diminishing number of Nile Perch catches in Kenyan waters, lack of storage facilities, unreliable power supply affecting ability to preserve fish, conflict between farmers and fishermen, occasional bad weather creating dangerous waves in the lake that destroys fishing equipment and prevents fishermen from monitoring their cages, and inability to raise capital required to start cage farming.

Within this multitude of issues, one of the greatest challenges is the inability to compete against imported products, due largely to the high cost of feed, which constitutes the single greatest contributor to high production costs. Figure 15 compares fish prices at various points in the value chain in Kenya (grey) to production costs in semi-intensive and intensive production systems (blue), as well as the cost of imported fish from various destinations (red). Evidently, in all three semi and fully intensive systems, the cost of production is similar to, or higher than the cost of imported Tilapia – depending on the size of imported fish. This is before accounting for any profits to the producer and is a key factor contributing to rising import volumes.

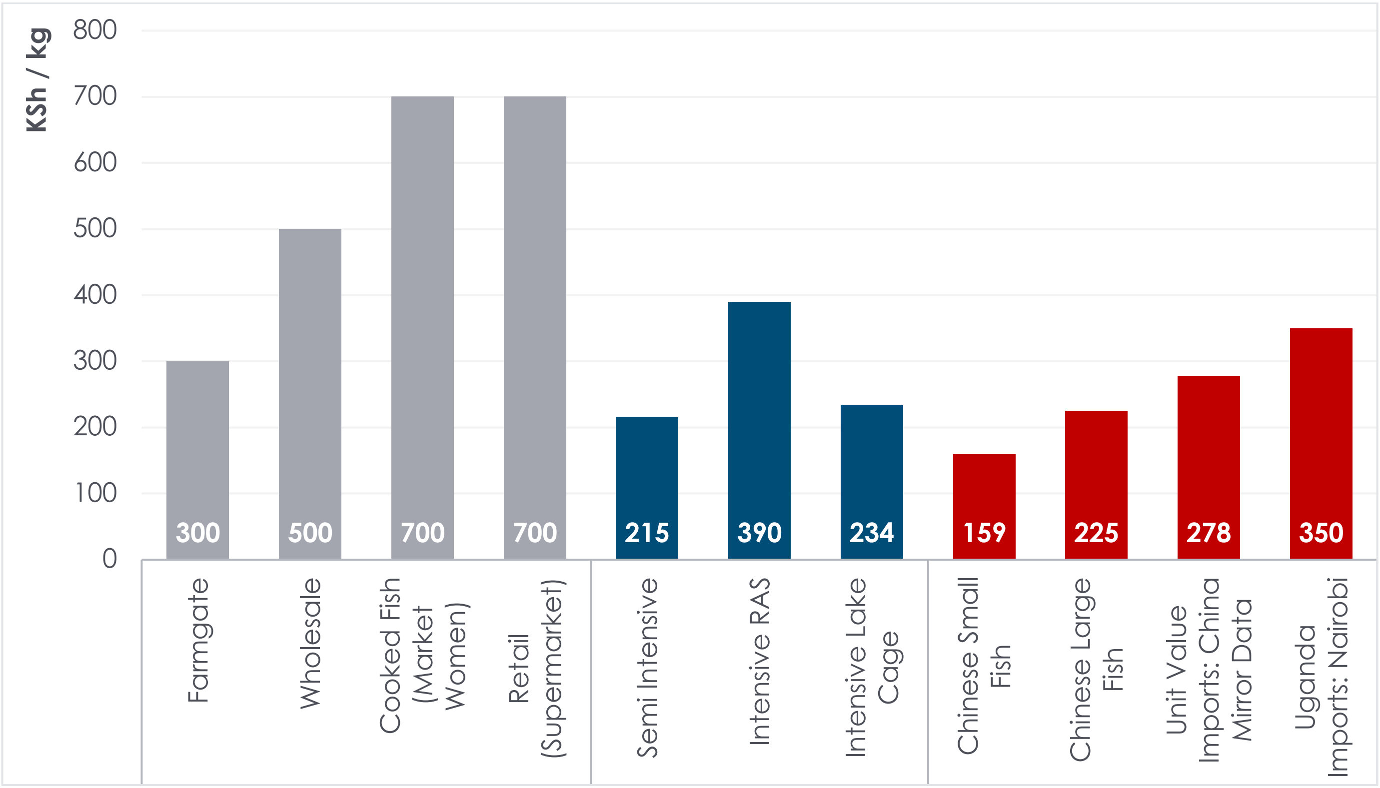

FIGURE 15: COMPARISON OF LOCAL PRICES, PRODUCTION COSTS AND IMPORT PRICES (KSH/KG)

As part of the deep dive analysis, an evaluation of producer margins indicated that, across all three systems, feed constituted the single biggest cost component. The share of feed in total costs ranged from 55% in highly intensive, recirculating air systems (RAS), to 71% in semi intensive systems and more than 90% in intensive cage based systems (Figure 16). Within the RAS system, the lower share of feed is attributed to additional costs such as electricity, which also brings additional risks due to inconsistent supply. The increased total costs associated with this system implies that producers need a substantial premium for the fish in order to enable a positive margin when producing fish for the market instead of fingerlings for farmers.

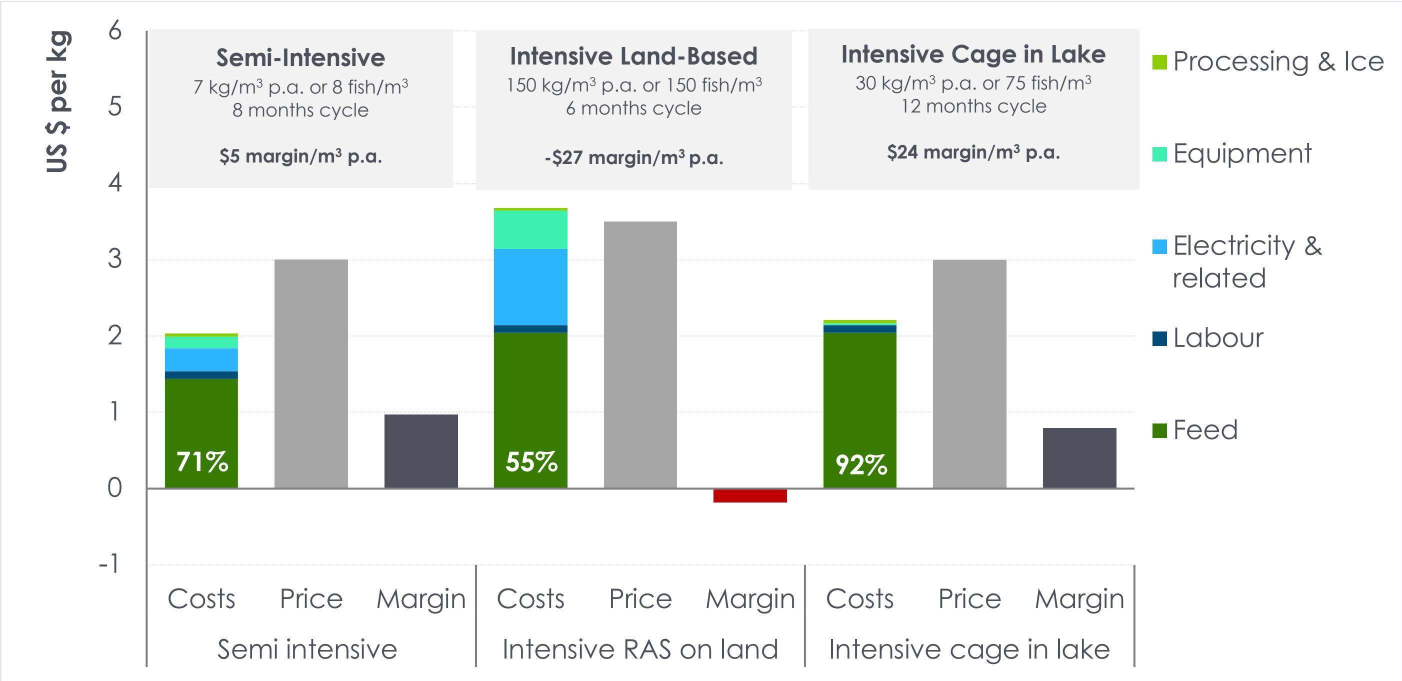

FIGURE 16: BREAKDOWN OF PRODUCER COSTS & ESTIMATED GROSS MARGINS (US$/KG)

Feed related challenges in the aquaculture sector are twofold. First is the high cost of domestically produced feed because many of the raw materials and pre-mixed vitamin and mineral packs are sourced outside of the region. The combination of transport, logistical costs and import duties all add to the cost of these products. A list of applied tariffs is provided in Table 9.

TABLE 9: IMPORT TARIFFS APPLIED TO SELECTED FEED PRODUCTS IN 2019

	East African Community (EAC)	Other (MFN)
Pre-mixes used in animal feed	0%	0%
Maize	0%	50%
Soybeans	0%	10%
Soybean oilcake	0%	10%
Fishmeal	0%	10%

Source: Market Access Map, 2021

Second is quality - stakeholders noted that, while the quality of domestically produced feeds is improving, it is not yet comparable to imported products. For this reason, many larger producers in Kenya rely on imported, pre-formulated feed, typically procured in Egypt or Zambia. While this yields more consistent performance, high transportation rates, combined with administrative and logistical fees all add to the cost and therefore contribute to the challenge of expensive feed rations. Table 10 further indicates that, despite these costs, domestically produced feed remains more expensive than imported feeds. In order to increase uptake of domestically produced feed, quality will need to improve to match imported products and prices will need to become more competitive.

Table 10: Prepared feed prices in Kenya - Q2 2020

	Imported feed ($/kg)	Local feed ($/kg)
Cost at source (Egypt)	$800	
Shipping & trucking	$150	
Administrative fees (4.5%)	$50	
Clearing/port fees	$50	
Total cost	$1050	$1100

Source: PPVC Gross Margin Analysis

Kenya's challenge of high feed costs is not unique to the aquaculture industry and emanates from its deficit in raw material production. Kenya is a net importer of most major raw materials used in the manufacture of animal feed, including maize, soybean meal and fish meal. This elevates prices, as raw materials are priced at import parity levels. Figure 17 indicates that raw maize and soybean meal can be procured at significantly lower cost in regions such as the USA, the Black Sea region or South America, but factors such as transport costs (both sea freight and inland), port and handling costs and tariffs all add to the import parity levels. Both soybean meal and maize sourced from outside of the East African Community carry significant tariffs of 10% and 50% respectively. In the case of maize, this is further exacerbated by the premium payable for non-GM maize. Non-GM maize can be sourced duty free in Uganda or Tanzania, but inland transportation rates remain a challenge and drive up costs.

In the case of fishmeal, which is an important protein source in fish feed, domestic production is limited, firstly because Omena is predominantly for human consumption, secondly because of regulation in order to mitigate juvenile capture and thirdly due to limited domestic processing of fish. The high cost of some raw materials, as well as imported vitamin and mineral packs also influence formulation and ultimate feed quality.

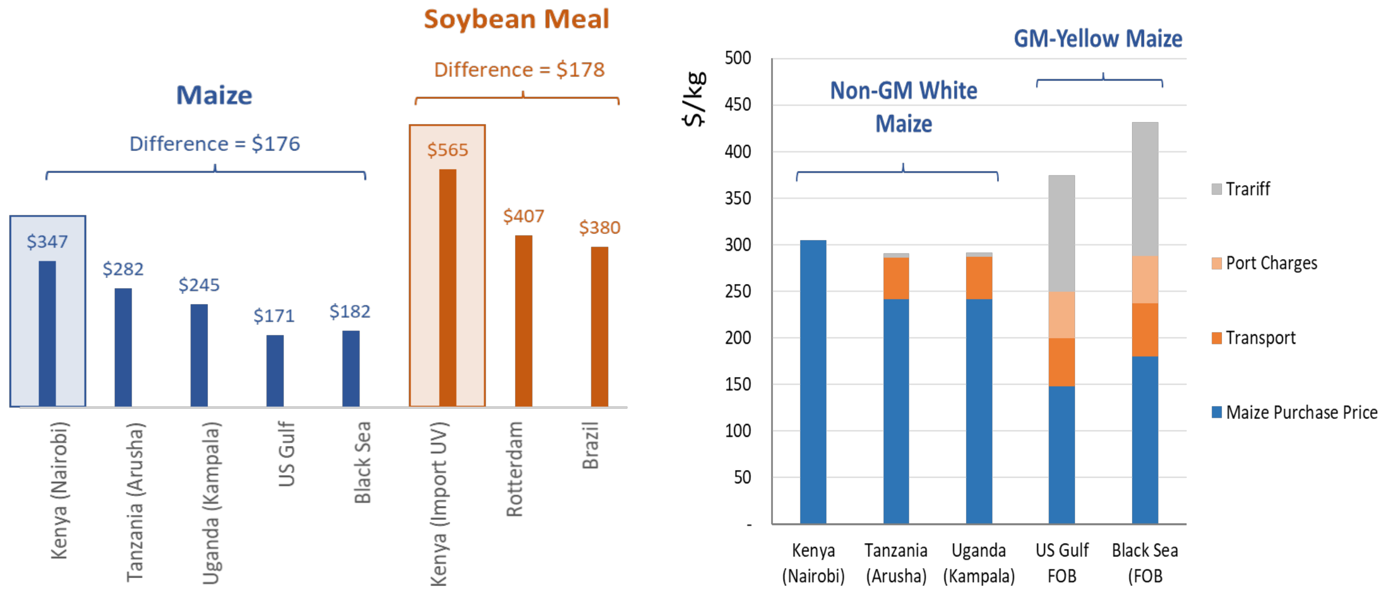

FIGURE 17: COMPARISON OF RAW MATERIAL COSTS SOURCED AT DIFFERENT DESTINATIONS

Source: FAO Giews Price tool, ITC Trademap & PPVC Gross Margin Analysis, 2021

Further to the feed and cost related challenges, many stakeholders also noted fingerling availability. Due to high demand and insufficient supply, hatcheries have opened that are not certified and, in many instances, quality standards have been compromised in order to meet volumes needs, which leads to poor performance.

4.2. Proposed interventions and investments to improve competitiveness

The deep dive analysis identified a number of priorities for investment and policy that can contribute towards improved competitiveness against imports and therefore expanded production. These priorities can be grouped into 6 distinct focus areas:

4.2.1. Feed and equipment cost reductions

In the short term, removal of import duties and administrative fees on fish farming equipment and pre-mixed animal feeds would reduce the cost of domestic production. Feed is the single largest contributor to input costs and removal of the current 4.5% administrative fee on imports will reduce costs, improve the competitiveness of fish production and initiate expansion, which in turn broadens the base for feed demand. This broader base then enables creation of scale advantages and improves the viability of investments into the domestic feed sector.

Another short term option to reduce the cost of feed is optimisation of rations, considering farmers' fish genetic pool and performance possibilities, together with the nutrient density required to optimize returns from that genetic pool and the most cost effective combination of raw materials to achieve that. This strategy would require investment in nutritional expertise, both within the feed sector, but also amongst extension staff.

In the medium term, the establishment of a high quality, competitive domestic feed industry must be incentivised. Increased fish production and a broader base of demand will help, but a reduction in raw material costs will also be required, which could entail multiple aspects:

- Removal of the import tariff on a quota of GM yellow maize for specific use in the feed sector will yield a US$ 55 per ton saving on maize, which comprises around 30% of typical rations. Kenya has used an average of 150 Kt maize per annum in the feed sector over past 3 years. Enabling the use of more affordable GM yellow maize in the feed sector will also imply that domestically produced, non-GM white maize can be milled for human consumption instead.

- Removal of the tariff on a quota of soybean meal for specific use in the feed sector can yield a 90 USD per ton saving on soybean meal, which comprises 30% of a typical ration.

- In the medium term, the development of feed raw material production, as well as investment in feed mill developments with scale benefits and optimal sourcing potential will be critical to a competitive feed sector.

Improvements in the quality of domestically produced feed will create broader procurement options for producers, improve performance and competitiveness and create more competition to drive down prices. Factors that can contribute to quality improvements include investment in modern feed production technologies, improved quality control on raw materials and monitoring of quality standards by regulatory authorities such as the Kenyan Bureau of Standards.

4.2.2. Import protection

In the short term, this entails improved import regulation & protection to allow the local fish industry to become more competitive. This can be justified on the bases of an infant industry that needs to grow to the extent where scale benefits can be achieved and a critical mass can be reached to incentivise investment into support sectors such as animal feeds. For illustrative purposes, simulations show the effect of increasing import tariffs on fish from 25% to 35%.

Ultimately, tariffs alone are not the answer to improved import competitiveness and in the medium term, streamlined legislature and governance, as well as improved policy coordination would be required, as the fish sector is regulated by a host of institutions, as shown earlier. Adherence to certification and quality standards was raised at various points of the value chain, including feed and fingerling production.

Further to direct imposition of duties, a supportive regulatory environment can also improve competitiveness against imported products. Multiple stakeholders noted a preference for domestically produced fish, which is seen as superior in quality by consumers. Consequently, regulations related to product information and labelling can enable producers to realise a premium for domestic products over Chinese imports, while also addressing concerns related to quality of imported fish.

4.2.3. Improved genetics for enhanced performance

Improvements to the genetic pool of the fish have significant potential to improve competitiveness through a shorter lifecycle, better feed conversion and also to enable an improved response from better and higher density feed.

In the short term, significant improvement in performance can be achieved through facilitation of improved genetic availability to domestic producers in the form of imported breeding stock. Such imports need to occur in a controlled environment, prioritising biosecurity and procurement of safe, disease free stock from leading global producers.

In the medium term, genetic improvements would require research and development, along with the provision of services to maintain and improve genetic diversity. Enabling improved genetics can also incentivize investment in breeding facilities, which will improve access to a consistent supply of fingerlings to producers that are not backward integrated. It will also contribute towards improved quality of fingerlings.

Further to genetic improvements, some performance gains can already be achieved by Information dissemination related to optimal species selection for various parts of Kenya, as specific species perform better in certain conditions.

4.2.4. Markets and processing

Presently, Kenya's fish market comprises predominantly whole fish, with limited downstream processing. Therefore, short term market related actions include investment in facilities where smaller producers can aggregate and sell their product, as well as cooling infrastructure for storage and transportation.

In the medium term, promotion and development of downstream value chains will be necessary when local production volumes increase. Processing infrastructure is critical in particular to unlock the potential of catfish, which is easier to produce, but not typically consumed whole. An expanded processing sector will also contribute to reduced feed costs, as it will provide domestically produced fish meal for use in rations.

4.2.5. Research and extension

Research and extension are both critical factors to drive longer term growth and development. From a research perspective, pooling and improved coordination of public, NGO and private institutions according to align with the same priorities will aid in accelerating returns.

Given that commercial aquaculture is a fairly young industry, significant benefits can be attained from investment in extension services. This includes upskilling and increasing the level of expertise, as well as increasing on-the-ground presence to improve production and feeding practices, as well as handling and processing. This will require county governments, which are the main driver of extension and training, to prioritise aquaculture, given its unique skillset requirements. County governments need to increase funding to extension initiatives, as well as Technical and Vocational Education and Training (TVET) to train and capacitate additional specialists

4.2.6. Zoning plan for Lake Victoria

Natural resource management is critical to sustainable fisheries, as well as aquaculture. With an increasing presence of farmed cages in major lakes, particularly Lake Victoria, a zoning plan that caps production at a sustainable utilization target within each zone will become increasingly important. This will provide assurance to operators that the environment will not degrade to unsustainable levels. This will also aid in managing competition for the resources in the lake as well as water quality.

4.3. Quantitative evaluation of improved state

The analysis of the possible impact from the suggested interventions is focussed on the first three, which are easier quantifiable and arguably easier to implement, at least in the short term. The impact assessment has three aspects: It starts with a gross margin analysis, which illustrates the impact of specified actions and interventions on margins within different production systems. Secondly, simulations were conducted using BFAP's multi-market partial equilibrium simulation model, which is described in Box 2. This enables quantification of the impact in terms of prices, revenue and returns, as well as the dynamic supply response that results from improved margins. Thirdly, this supply response, along with the gross margin impacts, are introduced into IFPRI's general equilibrium RIAPA model, detailed in Box 3, which simulates the economywide and development impacts.

Box 2: BFAP Africa multi market partial equilibrium model

The multi-market Partial Equilibrium (PE) model utilised in this analysis has been developed by the Bureau for Food and Agricultural Policy over a number of years. After initially starting with an ad hoc combination of country and commodity coverage that emanated from specific research requests for forward looking analysis in the region, the first comprehensive structure for grains and oilseeds in 8 countries was established in 2012. Over the period 2012-2015, BFAP also introduced the PE modelling methodology to the ReNAPRI network and researchers from in-country think-tanks received training in the application of these analytical tools. Over time, the model has been utilised in various research projects and expanded to the point where it now covers 12 countries, with commodity coverage in each country ranging from 1 to 15. The Kenyan module currently covers fifteen commodities, with relevant sectors linked through both competition for resources and input output relationships. For instance, livestock is linked to grains through animal feed and so scenarios that impact the livestock sector spill into grains and vice versa.

The multi market model is a dynamic, recursive partial equilibrium framework, based on balance sheet principles to establish equilibrium, where total supply (production, imports and stocks) must equal total demand (consumption, export and ending stock) for any given product. This approach, together with the analyses of market prices, provides the backbone for detailed market analysis that forms that foundation for the market-led approach of this project. The strengths of the partial equilibrium framework lie in the ability to capture intricate market and policy details, that closely mimick the situation for specific commodities. This also enables detailed scenario analysis when changes occur in any of the existing variables or relationships.

Model specification is generally based on well accepted structures and specifications of supply and demand, with prices based on a combination of import or export parity, and domestic supply and demand dynamics, depending on the market situation for each commodity. In commodities such as maize, where regional trade dynamics are important, the model also captures trade and pricing relationships within the region in an innovative trade specification detailed in Davids, Meyer and Westhoff (2018). The modelling framework ensures consistency in supply and demand relationships and is able to provide price impacts of alternative scenarios, as well as a dynamic supply and demand response over time.

Parameterisation is based on a combination of econometric estimation and elasticity assumptions based on literature review, theoretical consistency and specialist judgement. The model is calibrated based on historic data, with the period dependant on data availability and consistency. For the bulk of the commodities, the calibration period ranges from 2005 to 2019, but data limitations resulted in a calibration period of 2012 to 2019 for others.

The dependence on historic data, both for estimation and calibration purposes, implies that significant emphasis must be placed on the quality of the historic data feeding into the model. Initial commodity balance sheets were compiled based on a range of secondary data sources. While the official national data provided the starting point for balance sheet compilation, complementary data from the other listed sources provided opportunities for validation and alternatives where required.

BOX 3: IFPRI's economywide RIAPA model

IFPRI's Rural Investment and Policy Analysis (RIAPA) model is a dynamic economy-wide (or CGE) model that captures the interactions between all producers (sectors) and consumers (households) in the economy. RIAPA separates the Kenyan economy into 86 sectors (half within the agri-food system) and the Kenyan population into 15 household groups (i.e., urban, rural nonfarm, and rural farm, each further divided by per capita expenditure quintile). Producers in each sector combine intermediate inputs (e.g., fertilizers, seeds, fuels) with factor inputs (i.e., land, labour and capital) to produce a level of output, which they either consume within the household or supply to markets where they are combined with imports. Marketed products are either purchased by domestic agents (producers, households, government, investors) or exported to foreign markets. The decision to purchase domestic or imported goods and supply domestic or foreign markets depends on changes in relative prices in these different markets. Producers seeks to maximize profits and consumers seek to maximize utility (e.g., consumption). RIAPA, therefore, provides a comprehensive picture of the workings of the Kenyan economy, while also ensuring that macroeconomic consistency and resource constraints are respected.

Finally, the economy-wide model is linked to a survey-based microsimulation module that tracks changes in household incomes, consumption and poverty. The 2015/16 Kenya Integrated Household Budget Survey is used to build the CGE model's social accounting matrix (SAM) as well as the microsimulation module. The SAM captures the structure of the economy in 2017 using data compiled from the national statistical agency (e.g., national accounts) as well as other international sources, including the IMF (i.e., balance of payments and government financial statistics).

The RIAPA model is used to simulate the effects of expanding farm production within existing agricultural value-chains. Total factor productivity (TFP) growth in the farm component of each value-chain is accelerated beyond baseline growth rates, such that, in each value-chain scenario, total agricultural GDP is one percent higher in 2028 than it is in the "business-as-usual" baseline scenario. Expanding farm production increases the supply of raw agricultural products to downstream processing activities and generates demand for trade and transport services. Agricultural subsectors differ in size. To achieve the same absolute increase in total agricultural value-added (i.e. GDP), it is necessary for smaller value-chains to expand more rapidly than larger ones. Smaller subsectors need larger productivity gains to match the effects of bigger subsectors. While such rapid growth for these smaller subsectors may be difficult to achieve, targeting the same absolute increase in agricultural GDP permits comparisons across value chain growth scenarios.

The interventions are introduced incrementally in the model in order to illustrate the individual as well as the combined impact. The scenarios were quantified in three ways: Firstly the effect of changes in the gross margins of producers in various production systems is illustrated. Given limited use of commercial feed and other improved inputs, extensive producers were not considered in the gross margin analysis. Secondly, the market related impacts and supply response is simulated in the BFAP Africa multi-market partial equilibrium model. Thirdly, the broader economic and socioeconomic impacts of improved margins and expanded production is simulated using the economy-wide RIAPA general equilibrium model. The scenarios were defined as follows:

1) Removal of government fees (4.5%) on animal feed imports to reduce the cost of commercial pre-mixed feed
2) Increase the tariff on fish imports from 25% to 35% in order to improve short term competitiveness against Chinese imports and stimulate investment to unlock scale

advantage

3) Enabling imports of improved genetics, providing a 10% per annum gain in Feed Conversion and a 20% lifecycle decline over a period of three years
x) Combination of Scenarios 1-3, thus a 4.5% reduction in feed costs, increased import tariffs and improved performance enabled by better genetics
4) Combination of Scenarios 1-3, but with a larger (25%) reduction in feed costs, emanating from more competitive production domestically and implying that domestic feed can be produced at the same cost as in Egypt – thus saving all transaction costs associated with imports.

4.3.1. Gross margin impact

Figure 18 presents the changes in gross margins in each scenario on both the semi-intensive and the intensive cage based production systems. In the semi-intensive system, effects range from US$ 0.5 per m^3 per annum if feed import fees are removed to US$ 7.2 per m^3 per annum for the full combination of interventions. In the intensive cage based system, where feed accounts for a greater share of total cost, the effect is larger, ranging from US$ 2.6 per m^3 per annum when feed import fees are removed to US$ 29.3 per m^3 per annum for the full combination of interventions. While the substantial reduction in domestic feed costs is a longer term goal that must be achieved to improve the competitiveness of not only fish, but all intensive livestock industries, it will require longer term, sustained investment to achieve. From Figure 18 it is clear however that even a combination of the simpler interventions (Scenario X), will already yield a US$ 4.7 per m^3 per annum improvement in margins for semi-intensive producers and a US$ 16 per m^3 per annum improvement in margins for producers that use cages in the lake.

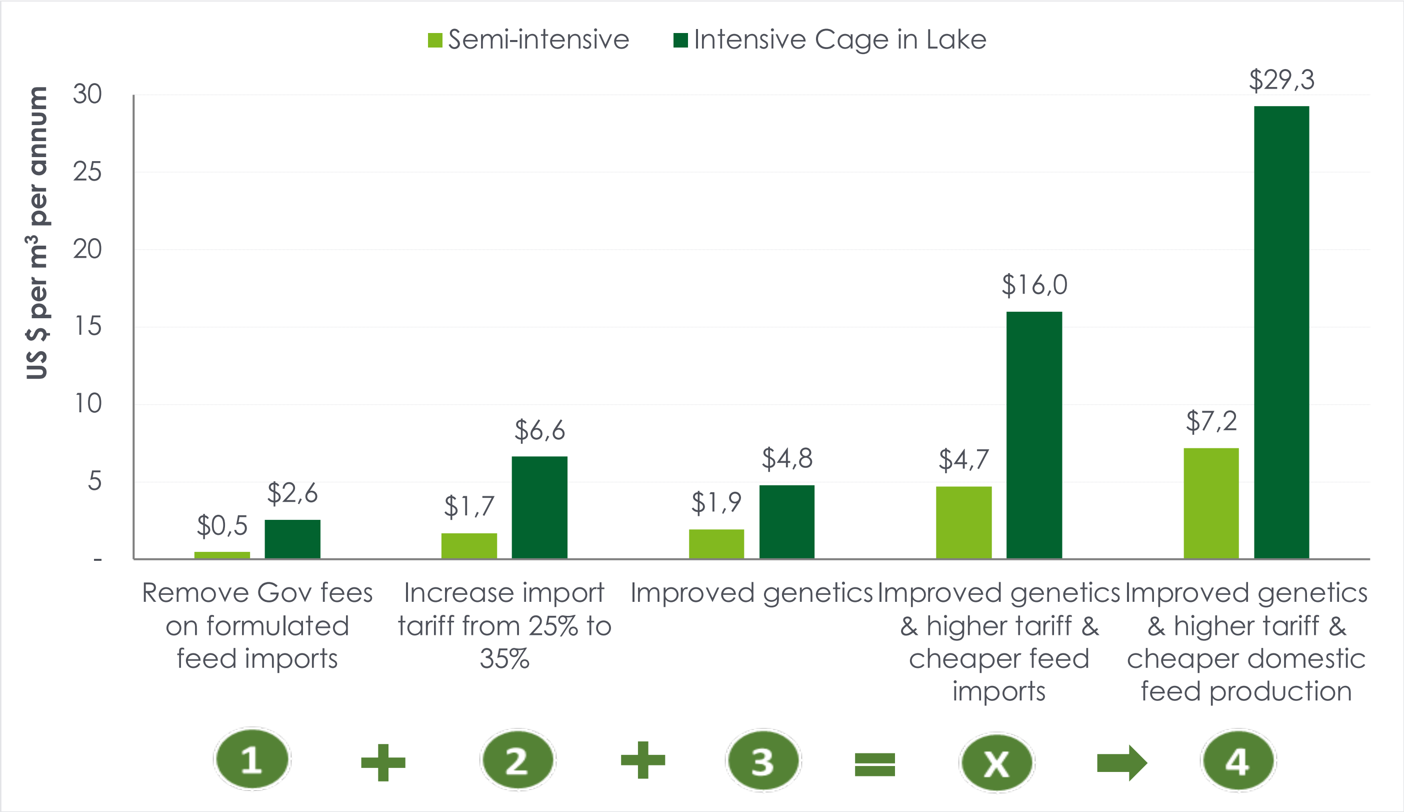

FIGURE 18: CHANGE IN GROSS MARGIN FROM UNDER VARIOUS SCENARIOS (US $ PER M³ PER ANNUM)

Source: PPVC value chain analysis

4.3.2. Market impact: Partial equilibrium market model simulations

Figure 19 presents the associated changes in production that result from improved margins for each of the specified interventions, relative to 2019 volumes, as well as the baseline (business as usual) projection for 2030. Under the baseline, aquaculture production of almost 27 000 tonnes would equate to only 9% of total demand for fish – similar to the current share contribution. If all interventions are implemented in combination, including lower cost production of high quality feed by a competitive domestic industry, this share can be increased to 24%, implying that aquaculture would contribute 72 000 tonnes to domestic fish production by 2030. This would reduce the need for imports by an estimated US$ 31.4 million per annum relative to the baseline.

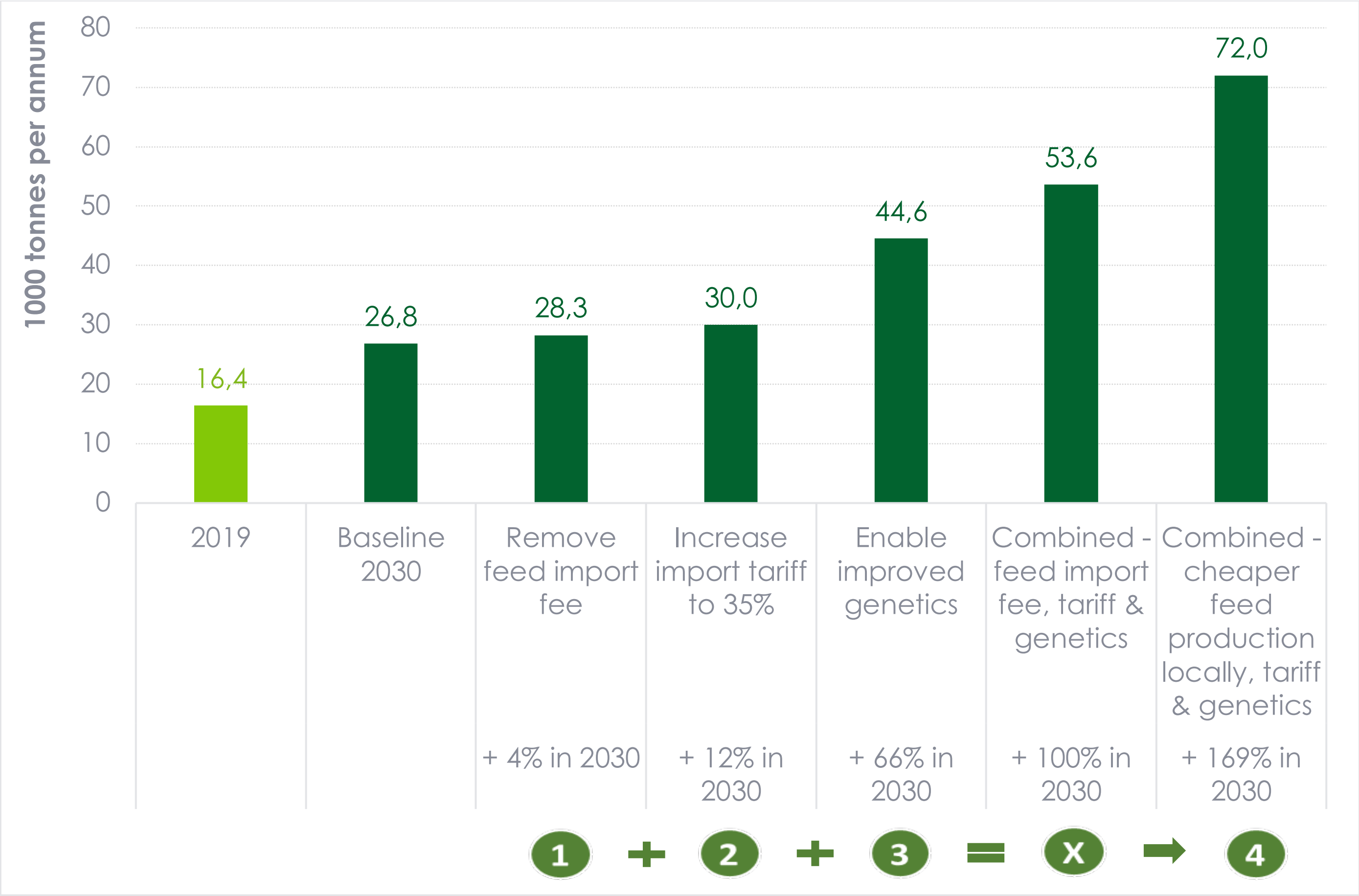

FIGURE 19: AQUACULTURE PRODUCTION IN 2019 COMPARED TO THE BASELINE PROJECTION FOR 2030 AND THE VARIOUS SCENARIOS

Source: BFAP Africa multi-market PE model

Figure 20 presents total fish production (capture and aquaculture), consumption and net imports of fish in Kenya under the combined scenario, which includes lower cost production of high quality feed by a competitive domestic industry, an increase in import tariffs from 25% to 35% and improved genetic imports to enable improvements in feed conversion and lifecycle. This is compared to the net imports under the baseline, illustrating the almost 60 000 ton reduction in import requirement under this improved state compared to the baseline. Some imports are still projected to occur, suggesting that prices will continue to be influenced by import parity levels, but domestic producers will capture a greater share of consumption growth by 2030.

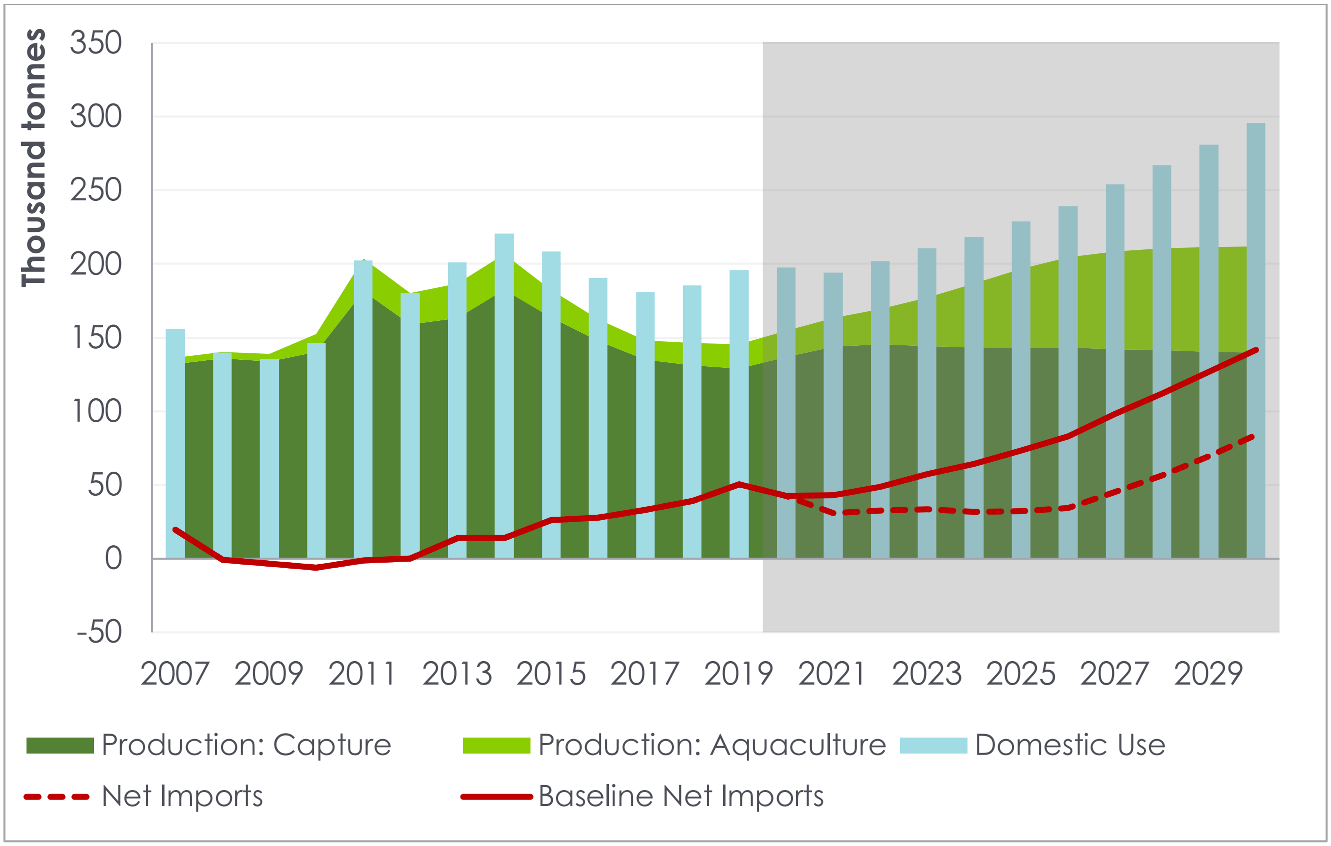

FIGURE 20: FISH PRODUCTION, CONSUMPTION AND TRADE IN KENYA UNDER THE COMPLETE IMPROVED STATE (SCENARIO 4)

Source: BFAP Africa multi-market PE model

4.3.3. Economy wide impact: RIAPA General Equilibrium simulations

Figure 21 presents the effects of the various combinations of interventions on the broader economy – measured in terms of impact on GDP, employment and poverty. It indicates clearly that the effects of a simple, single intervention such as the removal of government fees on imported imports is minimal, but implementation of the full combination of interventions under scenario 4 can add US $ 177 million to the agri-food system GDP by 2030. Similarly, this will generate 64 000 jobs within the agri-food system and reduce the number of poor people in Kenya by 79 000 by 2030. It is clear from Figure 21 that, while the largest GDP gains come from the establishment of a domestic feed industry, the combination of tariff reforms and genetic improvements already generate significant benefits, especially with respect to poverty reduction. It should be noted however that the development of a competitive domestic feed industry, while not a simple task, will also stand to benefit other sectors beyond aquaculture, such as poultry production and intensive beef finishing.

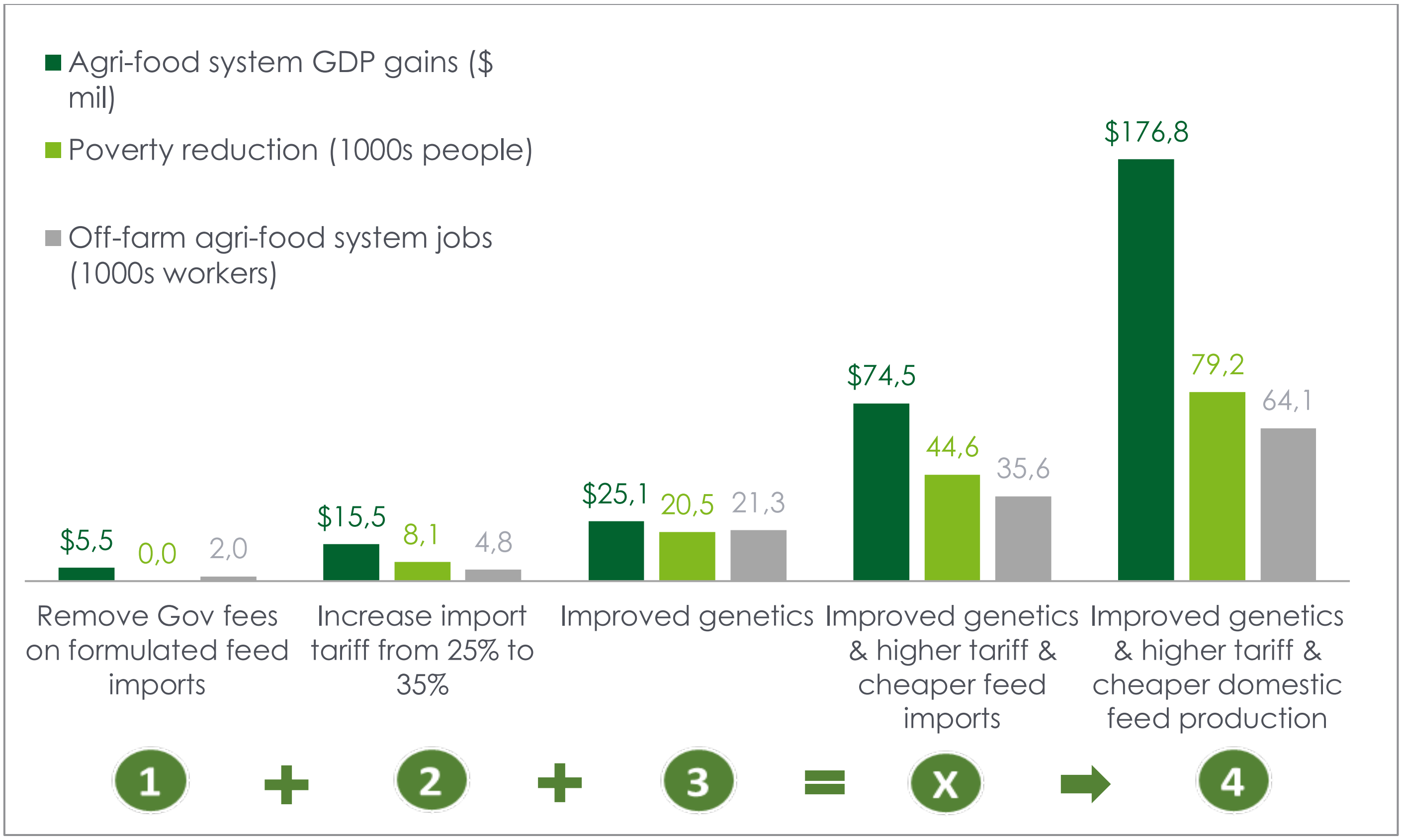

Figure 21: Impacts of various interventions on GDP, employment and Poverty by 2030

Source: IFPRI RIAPA Kenya economy wide model

IN CLOSING

5. CONCLUDING REMARKS

Within the context of Kenya's ASTGS and Big Four Agenda, the Policy Prioritisation through Value Chain Analysis (PPVC) project has prioritised a number of sectors with potential to guide and accelerate inclusive agricultural growth and transformation. As a second output in the project, this report set out a deep dive value chain analysis of the aquaculture sector, firstly by presenting a detailed structural and economic analysis of the aquaculture sector and the current state of the value chain, before presenting an improved state, with an associated list of investment and policy priorities to achieve it and a quantification of their impact.

The oceans and fisheries sector provides food, employment and income to a large share of Kenya's population, and it earns vital foreign currency through high quality fish exports. On a per capita basis, Kenya's fish consumption remains low, but a combination of income and population growth points to substantial growth in demand over the coming decade. This presents a major opportunity for growth in the sector, but in recent years domestic production has declined and the sector has been unable to supply additional demand, with imports filling the gap. Unless actions are taken to stimulate growth, future demand growth is likely to be captured by imports, costing significant foreign revenue and missing out on opportunities for exonomic growth and poverty reduction.

Currently the sector is largely based on freshwater fisheries, but declining capture as a result of numerous challenges in Lake Victoria and the finite nature of the resource suggests that future growth will need to be driven by aquaculture. Given its current low base, additional projected demand growth over the coming decade suggests that aquaculture will have to expand tenfold in order to generate sufficient supply.

Kenya's aquaculture sector has ample potential, but growth is constrained by a number of challenges, the greatest of which is the inability to compete with competitively priced imports, due in large to the high cost of feed. The challenge of high feed costs eminates from its deficit in raw material production and is compounded by the high cost of trade. In order to improve competitiveness of the sector, this report prioritised a number of actions, grouped in 6 broad categories, with detailed short and long term actions under each category.

1) Reduced input (particularly feed) costs
2) Import protection
3) Genetic improvements
4) Marketing and processing development
5) Research and Extension
6) A zoning and development plan for Lake Victoria to ensure sustainability

A number of short and medium term interventions were detailed, before quantifying the impact of reduced feed costs, import protection and genetic improvements through a combination of analytical tools. In an improved state, where feed costs are reduced to the level of competing countries such as Egypt or Zambia, genetic improvements result in a shorter lifecycle and improved feed conversion and import tariffs are increased to 35% from the current level of 25%, the impact can be summarised as follows:

1) Gross margins for a semi-intensive producer improve by US$ 7.2 per m^3 per annum and for a intensive cage based producer in the lake, by US$ 29.3 per m^3 per annum
2) Aquaculture production by 2030 increased by 45 thousand tonnes relative to the baseline, enabling it to supply 24$ of domestic demand by 2030, as opposed to only 9% under the baseline. This reduces the potential import bill by US $ 31.4 million.
3) By 2030, GDP from the agri-food system increases by US $ 177 million per annum above the baseline
4) By 2030, poverty is reduced by 79 000 people relative to the baseline
5) By 2030, 64 000 additional jobs are created in the agri food system relative to the baseline

From the quantitative analysis, it is clear that while the largest GDP gains come from the establishment of a domestic feed industry, a combination of tariff reforms in the animal feed sector and genetic improvements, which are enabled by facilitating imports of top genetic material from leading producers already generate substantial benefits, especially with respect to poverty reduction. It should be noted, however, that the development of a competitive domestic feed industry, while not a simple task, will also stand to benefit other sectors beyond aquaculture, such as poultry production and intensive beef finishing. There is thus compelling evidence, both at farm, market and economywide levels, that establishing a competitive smallholder-oriented aquaculture sector in Kenya could become another much-needed engine for broad-based agricultural transformation and national economic development.

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7. ANNEXURE A: OVERVIEW OF PPVC METHODOLOGY

In most developing countries, the formulation of sound economic policies that establish a framework and enabling environment for agricultural transformation and inclusive economic growth is high on the agenda. However, appropriate and effective public policies and investments require strategies that are targeted and recognise budgetary constraints. To this end, many governments develop national agricultural investment plans (NAIPs) or strategic reforms that outline the Ministry of Agriculture's policy and investment priorities. While these initiatives are a positive step towards formalising the process of priority-setting and budgeting, they can often lead to long lists of policy ambitions and substantial increases in proposed levels of public agricultural expenditure.

Against this backdrop, the Bill and Melinda Gates Foundation (BMGF) is supporting a replicable, market-led, evidence-driven Policy Prioritisation through Value Chain Analysis (PPVC) project. The project is implemented by the Bureau for Food and Agricultural Policy (BFAP) in partnership with the Alliance for a Green Revolution in Africa (AGRA), the International Policy Research Institute (IFPRI), and in-country think tanks. The PPVC approach was developed by BFAP and IFPRI during a pilot project in Tanzania in 2017 and 2018 that was executed in collaboration with Sokoine University of Agriculture, Morogoro, Tanzania. The approach was developed to (1) identify value chains that can increase incomes, ensure food and nutrition security, attain higher agricultural GDP growth, create jobs and employment and other outcomes related to inclusive agricultural transformation (IAT); and (2) prioritise and implement policies and public investments for upgrading the identified value chains. The initiative is set up to follow a demand driven approach in relation to the identification and prioritisation of policy options, and upon the explicit request from national governments and other relevant stakeholders, and focuses on capacity building of in-country think-tanks. The project has been implemented in Tanzania, Kenya, and the first set of outputs have been developed for Ethiopia and Nigeria.

This project does not replace the national plans or any ongoing value chain and policy prioritisation activities, but rather augments the process by providing a unique combination of empirical tools within a market-led approach. The broad activities or interventions to be delivered by the Project include:

- **Market-led analysis to identify value chain priorities.** On-the-ground value chain mapping, and partial and computable general equilibrium modeling to generate a market outlook and identify and assess priority value chains that align to national strategies and that have the potential to drive IAT.
- **Policy and public investment reform identification, prioritisation and design.** Articulation and sequencing of policy and public investment reforms for upgrading each prioritised value chain.
- **Technical assistance on implementation of reforms.** Provision of ongoing technical assistance to governments on the implementation of policy and public investment recommendations, as follow-up support for ensuring that recommendations are implemented after technical findings are presented.

Broadly, the PPVC approach covers two key aspects, which can run concurrently, each with multiple phases. The first aspect relates to **cross-cutting sectoral priorities** and the second is focussed on **value chain specific priorities**. Under the various phases, the approach combines a number of qualitative and quantitative assessments. Figure 1 presents the overall framework where a combination of market-led and economy-wide outcomes inform the selection and analysis of priority value chains and cross-cutting policies and investments that are most effective at driving sustainable inclusive agricultural transformation.

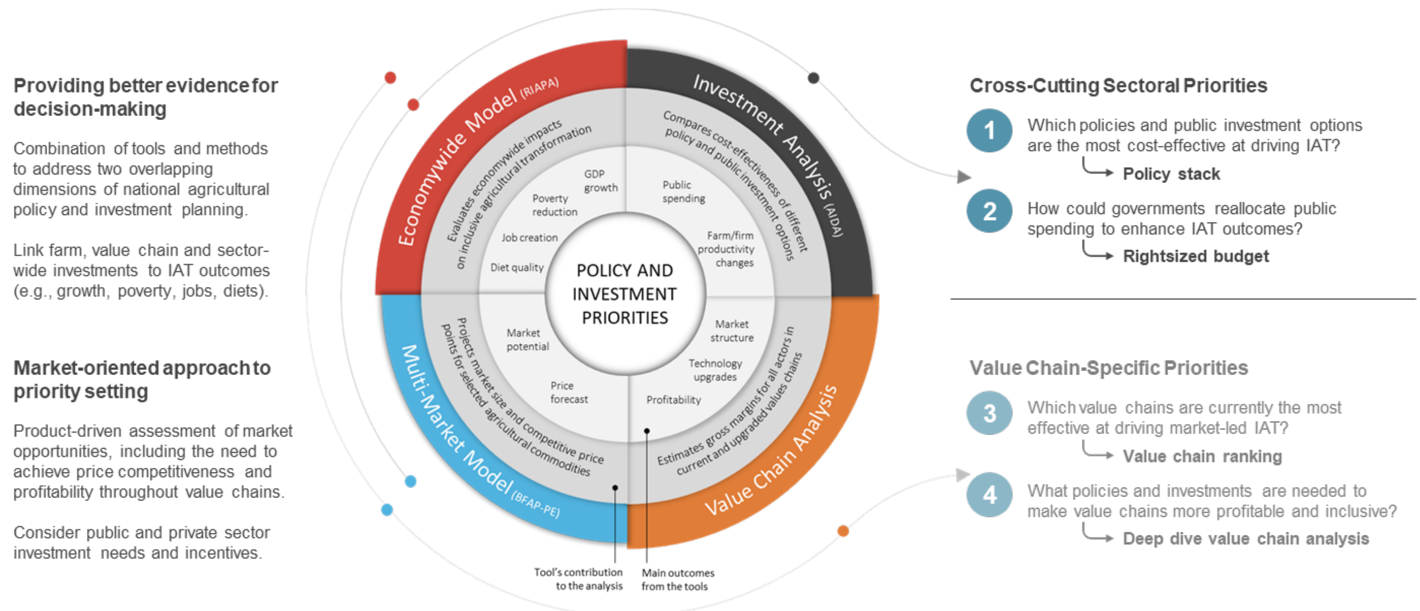

Figure A1: Overview of the tools utilised in the PPVC approach.

1. Cross Cutting Sectoral Priorities

The cross cutting sectoral priorities is an investment analysis conducted by IFPRI using the RIAPA-AIDA framework. It comprises two phases designed to compare the cost effectiveness of various relevant policy and public investment options. It considers the quantum of government expenditure, as well as the farm and firm level productivity gains that the expenditure is expected to unlock. The first phase develops a policy stack, based on the cost effectiveness of various options in driving inclusive agricultural transformation (IAT). The second phase develops a rightsized budget, which considers expenditure constrains and therefore reallocates public expenditure in order to optimise and enhance IAT outcomes.

AIDA requires information on investment impacts, unit costs and public spending. Econometric analysis of farm and household survey data is first conducted to analyze household-level investment impacts. This is combined with information from secondary sources, including monitoring and impact evaluation (M&E) studies of past investments and programs, and/or from spatial crop and infrastructure modeling. AIDA then decomposes and analyzes government budgets using public expenditure data, and projects future changes in spending allocations and investment impacts.

This information is fed into RIAPA, which analyzes the economywide impacts of AIDA's investment spending forecast, alongside changes in market and macroeconomic policies. Finally, RIAPA's microsimulation module estimates household-level poverty and dietary impacts differentiated by gender.

The estimates of the returns to different investments is then used to prioritize the allocation of public spending given resource constraints (i.e., budget rightsizing). This is an iterative process in which investment impacts and returns are re-estimated over time, allowing the prioritized budget to evolve over the planning period in response to changes in investment outcomes and costs.

2. Value Chain Specific Priorities

Value Chain Specific Priorities involve research undertaken by BFAP, IFPRI and in-country think tanks with AGRA facilitating discussions with key in-country stakeholders. The analytical work also comprises two phases, designed to prioritise specific value chains to maximise impact on IAT outcomes, as well as specific actions within these value chains to ignite inclusive growth.

2.1 Value Chain Ranking

The first phase of the value chain specific priorities is the development of a ranking report. The ranking exercise considers current policy initiatives and therefore typically, but not exclusively, starts with a shortlist of value chains identified in existing policy documents such as the National Agricultural Investment Plans. The value chains included in this short list is then ranked based on a selection of quantitative indicators, informed by historic data and the modelling framework, related to market led potential, inclusiveness, transformation and a qualitative scan of the value chains that considers four key elements for each chain: (1) The current and potential investment level of each value chain; (2) the scalability of a value chain taking account of potential in regional markets and in downstream or complementary value chains; (3) the existing level of policy support; and 4) Agro-ecological resource potential related to the specific chain. Table 1 provides a summary list of indicators.

Table A1: Summary of Value Chain Ranking Indicators

Indicator Category	Indicator Sub-Category	Indicator Name / Description	Analytical Framework
Market-led potential	Market Potential	Potential for intensification	BFAP Africa PE Model
		Domestic consumption growth	BFAP Africa PE Model
		Regional Export Potential	Historic Data
	Competitiveness	Relative Trade Advantage (RTA)	Historic Data
		Input cost to use ratio	Historic Data
Inclusiveness		Poverty Reduction	RIAPA CGE Model
		Agri-food System Employment	RIAPA CGE Model
Transformation		Agri-food system growth	RIAPA CGE Model

		Diet Quality	RIAPA CGE Model
Value Chain Scan	Qualitative Feedback in country	Level of Policy Support	Qualitative Ranking through Stakeholder Engagement
		Private sector investment levels	
		Scalability and interlinkages with additional value chains	
		Agro-econological Resource Base	

The various indicators are combined using a Garrett Ranking technique. The indicators inform a ranking outcome for each category. These can be regarded as orders of merit assigned to value chains through the indicators. Orders of merit are transformed into units of scores by converting orders of merit to percentage positions and converting percentage positions to scores using the Garrett table (Garrett & Woodworth, 1985). Finally, scores are added for each factor (value chains in our case) and divided by the total number of indices used. The final ranking of value chains is assigned according mean scores: highest mean score ranking first and lowest mean score ranking last.

Value chain selection is informed by the ranking, but occurs in collaboration with stakeholders and policy makers in country. In the various countries where the approach has been rolled out to date, the ranking was a key consideration in choosing relevant value chains, but the choice was also informed by urgency and need for actions from policy makers. Consequently, while higher ranking value chains have been chosen, it has not simply come down to choosing the highest ranking value chains for deep dive analysis.

2.2 Value Chain Deep Dive

The deep dives provide an in depth analysis of specific value chains and follows the initial selection process. Essentially, it aims to inform which policies and investments are needed to unlock improved profitability, inclusivity, efficiency and therefore growth from these value chains. The value chain deep dive process proceeds sequentially as follows:

- Firstly, it aims to establish the current state, as well as the baseline, or "business as usual" outlook for the specific subsector. This provides an overview of historic and expected supply and demand trends (including trade flow and prices), identifies critical stakeholders throughout the value chain, and establishes associated market shares, operational costs, capacities and constraints. This all informs a summary of major challenges and constraints faced by the various value chain actors.
- Secondly, it defines an "ideal or improved state" for the value chain, in which key bottlenecks and constraints are addressed using specific levers of change, including but not limited to value chain investments (public and private) and policy levers. In order to reach the ideal state, a combination of investments and policies are formulated at specific nodes of the value chain aimed at unlocking more value out of the market system and to boost the level of participation/inclusiveness.
- Thirdly, the impacts of the changes are quantified in three ways.
    - Changes are translated to gross margin impacts at the various nodes of the value chain.

- The impact of interventions is modelled over a medium-term horizon (10 years), using BFAP's multi-market partial equilibrium model, which informs the projected product flow through the value chain.
- The broader economic and socioeconomic impacts of improved margins and expanded production is simulated using the economy-wide RIAPA general equilibrium model.

2.3 Quantitative tools utilised in the analysis

The value chain specific analysis relies on a package of empirically-grounded tools designed to answer key questions at different stages of the policy process. These tools include four main components, namely a multi-market model (BFAP); an Integrated Value Information System (IVIS); an economy-wide model (RIAPA-AIDA); and value chain mapping and gross margin analysis. The Integrated Value Information System provides a platform that integrates global spatial datasets with the empirical output of the other tools. The Value Chain Analysis identifies key actors and products flows and provides gross margins at various points of the chain to inform investment needs and feasibility. The BFAP multi-market partial equilibrium model projects market space and competitive price points for the specific commodities, whereas the RIAPA economywide model evaluates broader economic and socioeconomic impacts on inclusive agricultural transformation. The specific tools are detailed below. While each tool has its own merits, the strength of the PPVC approach rests in the combination, which is ultimately used to assess impact and prioritise actions. The combination of the multi-market PE model, IVIS and value chain analysis enables the identification and costing of public and private investments in agriculture and downstream agro-processing. The value chain analyses adopts a product-driven or market-led approach which extends from local farmers to final consumers or export markets, and the farm component of each value chain is situated within the broader agricultural sector (but not the economy as a whole). IVIS highlights where value chains could potentially be located in a country and the PE model assesses impacts on agricultural production and prices. In turn, RIAPA captures the whole economy, including both agricultural and downstream subsectors, and how these combine to form a country's agri-food system (AFS).

Integrated Value Information System (IVIS)

IVIS was developed to integrate economic, statistical and spatial modelling approaches into a single system designed to answer the kinds of policy and business questions needed to design a feasible public-private investment plan. IVIS is hosted in a secure web-based geographical information system that facilitates better project governance, including real-time monitoring and evaluation using BFAP's economic models and databases.

BFAP Multi Market Partial Equilibrium Model

The multi-market Partial Equilibrium (PE) model utilised in this analysis has been developed by the Bureau for Food and Agricultural Policy over a number of years. After initially starting with an ad hoc combination of country and commodity coverage that emanated from specific research requests for forward looking analysis in the region, the first comprehensive structure for grains and oilseeds in 8 African countries was established in 2012. Over the period 2012-2015, BFAP also introduced the PE modelling methodology to the Regional Network of Agricultural Policy Research Institutes (ReNAPRI) and researchers from in-country think-tanks received training in the application of these analytical tools. This training is repeated and strengthened in countries where the PPVC project is implemented, for example Tanzania and Kenya. Over time, the model has been utilised in various research projects and expanded to the point where it now covers 12 countries, with commodity coverage in each country ranging from 1 to 15. The model typically covers ten to fifteen main commodities, with relevant sectors linked through both competition for resources and input output relationships. For instance, livestock is linked to grains through animal feed and so scenarios that impact the livestock sector spill into grains and vice versa.

The multi market model is a dynamic, recursive partial equilibrium framework, based on balance sheet principles to establish equilibrium, where total supply (production, imports and stocks) must equal total demand (consumption, export and ending stock) for any given product. This approach, together with the analyses of market prices, provides the backbone for detailed market analysis that forms that foundation for the market-led approach of this project. The strengths of the partial equilibrium framework lie in the ability to capture intricate market and policy details, that closely mimic the situation for specific commodities. This also enables detailed scenario analysis when changes occur in any of the existing variables or relationships.

Model specification is generally based on well accepted structures and specifications of supply and demand, with prices based on a combination of import or export parity, and domestic supply and demand dynamics, depending on the market situation for each commodity. In commodities such as maize, where regional trade dynamics are important, the model also captures trade and pricing relationships within the region in an innovative trade specification detailed in Davids, Meyer and Westhoff (2018). The modelling framework ensures consistency in supply and demand relationships and is able to provide price impacts of alternative scenarios, as well as a dynamic supply and demand response over time.

Parameterisation is based on a combination of econometric estimation and elasticity assumptions based on literature review, theoretical consistency and specialist judgement. The model is calibrated based on historic data, with the period dependant on data availability and consistency. For the bulk of the commodities, the calibration period ranges from 2005 to 2019, but data limitations resulted in a calibration period of 2012 to 2019 for others.

The dependence on historic data, both for estimation and calibration purposes, implies that significant emphasis must be placed on the quality of the historic data feeding into the model. Initial commodity balance sheets were compiled based on a range of secondary data sources. While the official national data provided the starting point for balance sheet compilation, complementary data from the other listed sources provided opportunities for validation and alternatives where required.

IFPRI Economywide RIAPA Model

IFPRI's Rural Investment and Policy Analysis (RIAPA) model is a dynamic economy-wide (or CGE) model that captures the interactions between all producers (sectors) and consumers (households) in the economy. RIAPA separates the Kenyan economy into 86 sectors (half within the agri-food system) and the Kenyan population into 15 household groups (i.e., urban, rural nonfarm, and rural farm, each further divided by per capita expenditure quintile). Producers in each sector combine intermediate inputs (e.g., fertilizers, seeds, fuels) with factor inputs (i.e., land, labour and capital) to produce a level of output, which they either consume within the household or supply to markets where they are combined with imports. Marketed products are either purchased by domestic agents (producers, households, government, investors) or exported to foreign markets. The decision to purchase domestic or imported goods and supply domestic or foreign markets depends on changes in relative prices in these different markets. Producers seeks to maximize profits and consumers seek to maximize utility (e.g., consumption). RIAPA, therefore, provides a comprehensive picture of the workings of the Kenyan economy, while also ensuring that macroeconomic consistency and resource constraints are respected.

Finally, the economy-wide model is linked to a survey-based microsimulation module that tracks changes in household incomes, consumption and poverty. Integrated Household Budget Surveys are used to build the CGE model's social accounting matrix (SAM) as well as the microsimulation module. The SAM captures the structure of the economy using data compiled from the most recent national statistical agency (e.g., national accounts) as well as other international sources, including the IMF (i.e., balance of payments and government financial statistics).

The RIAPA model is used to simulate the effects of expanding farm production within existing agricultural value-chains. Total factor productivity (TFP) growth in the farm component of each value-chain is accelerated beyond baseline growth rates, such that, in each value-chain scenario, total agricultural GDP is one percent higher in 2028 than it is in the "business-as-usual" baseline scenario. Expanding farm production increases the supply of raw agricultural products to downstream processing activities and generates demand for trade and transport services. Agricultural subsectors differ in size. To achieve the same absolute increase in total agricultural value-added (i.e. GDP), it is necessary for smaller value-chains to expand more rapidly than larger ones. Smaller subsectors need larger productivity gains to match the effects of bigger subsectors. While such rapid growth for these smaller subsectors may be difficult to achieve, targeting the same absolute increase in agricultural GDP permits comparisons across value chain growth scenarios.

Value Chain Analysis

The value chain analysis encompasses the entire deep dive process, combining gross margin assessments, product flow, processing and handling capacity, trading volumes and platforms, partial and general equilibrium modelling frameworks and spatial dimensions. The final outcomes provide a granular view of all products and actors, as well as the economics of the value chain, including operating margins derived from input costs and output and import/export parity prices. A key feature is the development of the potential state, which considers how the value chain could be restructured and optimised to enhance competitiveness, profitability and transformational outcomes. Identifying the potential state of the value chain is made possible by engaging industry specialists and private sector actors with local and international knowledge and expertise.