Unlocking Potential for Development of Kenya's Aquaculture Sector

Abstract

The Kenyan fish industry has vast potential to boost economic growth, create jobs, and enhance producers' welfare. However, the industry finds itself at a critical juncture. Domestic producers are unable to meet the demand for approximately 185,000 tons of fish consumed in Kenya. The recent contraction in domestic supply, primarily due to reduced catch from Lake Victoria, which is plagued by overfishing and pollution, has led to a rapid increase in competitively priced fish imports, which have been growing in their share of the domestic market.

As part of the Policy Prioritization through Value Chain Analysis (PPVC) analysis, a deep-dive analysis of the aquaculture value chain revealed that Kenya could substitute fish imports worth up to US$30 million per year. This transformation is expected to generate an estimated US$177 million in agri-food system GDP.

To achieve this transformation, the analysis recommended duty waivers for imported raw materials used in livestock feed, lifting the ban on genetically modified (GM) products, developing supportive regulations for GM imports and production, ensuring fair competition for inexpensive fish imports, and investing in research and development to enhance genetics, improve the production environment, and upgrade marketing infrastructure.

Building on these recommendations, the government permitted a duty waiver for raw materials used in the manufacturing of livestock feed, but did not remove the GM restrictions. Nevertheless, this measure did not improve competitiveness in livestock feed manufacturing or the associated livestock value chains. Rising global prices, exchange rate shocks, and unfavourable business costs (including taxes, fuel, labour, and energy) impeded progress. Conversely, the measures to restrict imports through tariffs were effective in enhancing the competitiveness of locally produced fish. Limiting exports has been crucial to increasing investments in cage farming. However, investments aimed at improving genetics and marketing infrastructure are yet to be implemented.

1. Introduction

The fisheries sector plays a vital role in the Kenyan economy. It provides food, employment and income 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 161,000 metric tons (MT) (Fisheries Annual Statistical Bulletin, 2024), valued at approximately KES 36 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 1.5 million fishers, traders, processors, input suppliers, merchants of fishing accessories and providers of related services directly and indirectly (Fisheries Annual Statistical Bulletin, 2024). 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 use fish by-products as raw materials.

Fish production in Kenya has remained volatile in the past years due to policy changes and weather shocks (Figure 1). Production increased in 2018 due to favourable weather, leading to an increase in capture fisheries output. However, this declined from 2021 due to unfavourable weather. Over the past five years, aquaculture output has increased, driven mainly by increases in cage farming output. Imports have declined over the past three years due to policy changes that have restricted imports.

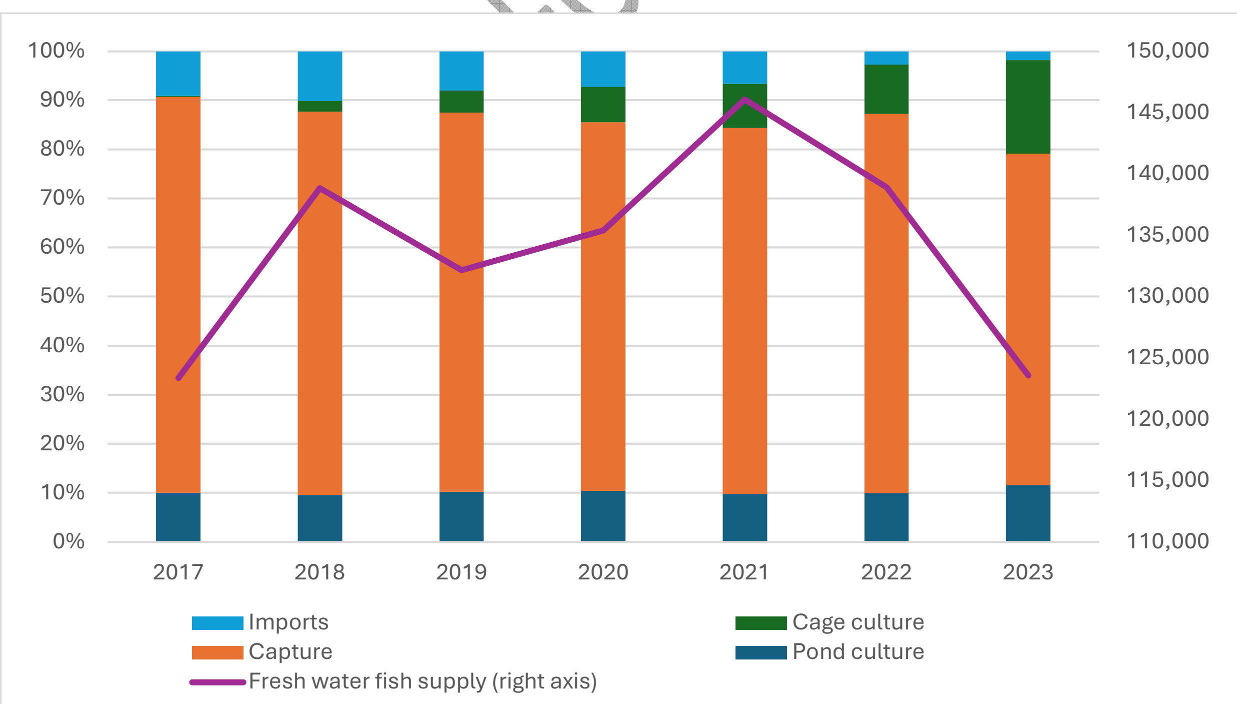


Figure 1: Trends in fish production by source

Source: Data from Fisheries Annual Statistical Bulletin, 2024

The country has a reported annual deficit of 340,000 tonnes of fish against an estimated annual demand of 500,000 tonnes (KNBS, 2023). However, local consumption has rarely breached the 200.000 tons 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 fulfil domestic demand.

Kenya imports Tilapia and Mackerel from China, which are cheaper than domestically farmed or captured 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. 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 fish consumption 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 are the county's inability to satisfy demand, coupled with high prices for high-quality export products. Fish is a critical source of affordable animal protein, and its consumption has increased due to the health-conscious behaviour of individuals and households and initiatives such as the Eat More Fish Campaign, which was launched by the President of Kenya in November 2018. The State Department of Fisheries spearheaded this, seeking to increase the 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.

Expected growth in both income levels and the size of the population points to ample additional demand over the coming decade. The rapid growth in fish consumption is expected to lead to substantial market opportunities, but in order to meet this demand, domestic production must substantially rise, without which the country's reliance on imports will significantly increase.

The nature and composition of Kenya's fisheries resources are concentrated 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 practiced across the country, on land and in water bodies. Kenya is also endowed with many rivers found in high and low altitude areas. Lakes, dams and rivers also support recreational fishing (State Department for Fisheries, Aquaculture and the Blue Economy, 2018).

Inland water fishing is done mainly in Lakes Victoria, Turkana, Baringo, Naivasha, Jipe and Chala as well as dams along the Tana River. 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's exclusive fishing zone can yield 300,000 tons of fish annually, valued at KES 75 billion. However, a lack of deep sea fishing gear and vessels restricts Kenyan fishermen to operating within five nautical miles from shore. 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 are also often for subsistence purposes, undertaken by artisanal fishers in the shallow waters and within the reef using small, non-mechanized fishing crafts. KEMFSED (2019) estimates that approximately 80% of marine products originate from coastal waters and reefs, with the remaining 20% sourced from offshore fishing. Artisanal fishing is characterized by small crafts propelled by sails, 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).

1.1. Evolution of aquaculture development

According to Obwanga et al. (2020), the history of Kenya's aquaculture sector can be divided into three distinct phases: the introductory phase from 1920 to 1950, the donor and government support phase spanning 1960 to 2000, and the private sector–led phase from 2010 onwards. Aquaculture began in Kenya during the 1920s, initially introduced by colonialists for sport fishing, which later transitioned to fish farming in static water ponds. In 1948, the Kiganjo trout hatchery was established to support the cold-water fishery and recreational industry. Subsequently, warm water fish farming was initiated in Sagana, accompanied by establishing a hatchery to provide quality brood stock for local farmers and enhance their aquaculture skills (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 for 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 2). 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).

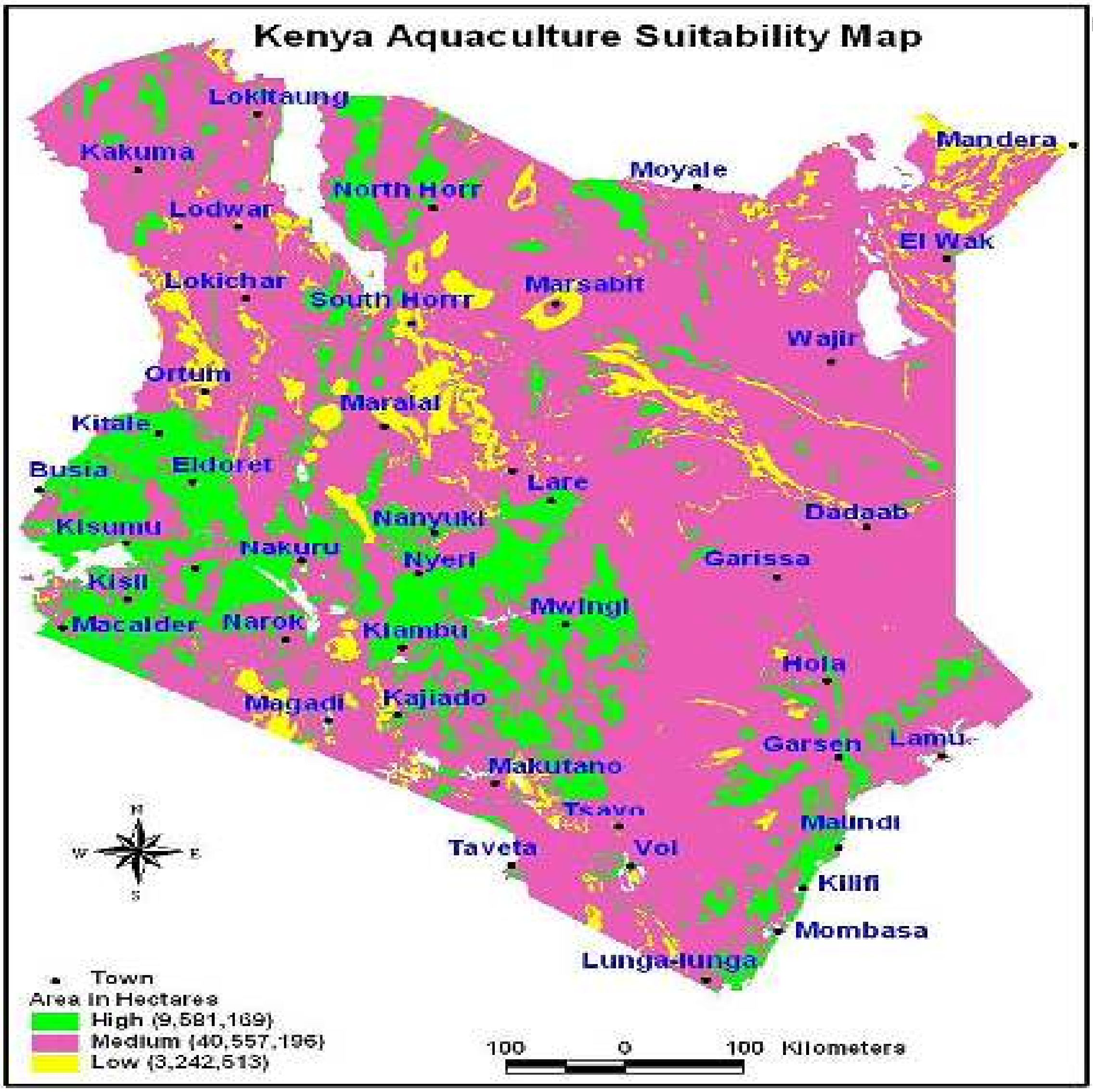


Figure 2: Areas suitable for freshwater aquaculture in Kenya

Source: Ogello and Munguti, 2016.

The ESP led to a swift rise in fish farming participation among farmers, with aquaculture areas expanding from 722 ha in 2008 to 2,076 ha by 2013. . However, statistics show that over 50,8100 aquaculture farmers, although both the number of operational ponds and overall production have declined. Aquaculture farmers are unevenly distributed across the counties, with high concentration of farmers in the western and central Kenya regions (Figure 3). The top two counties, Kakamega and Bungoma counties account 23% of the farmers, with top 10 counties accounting for 56% of farmers. Twenty-eight counties out of the 47 counties had fewer than a thousand farmers each.

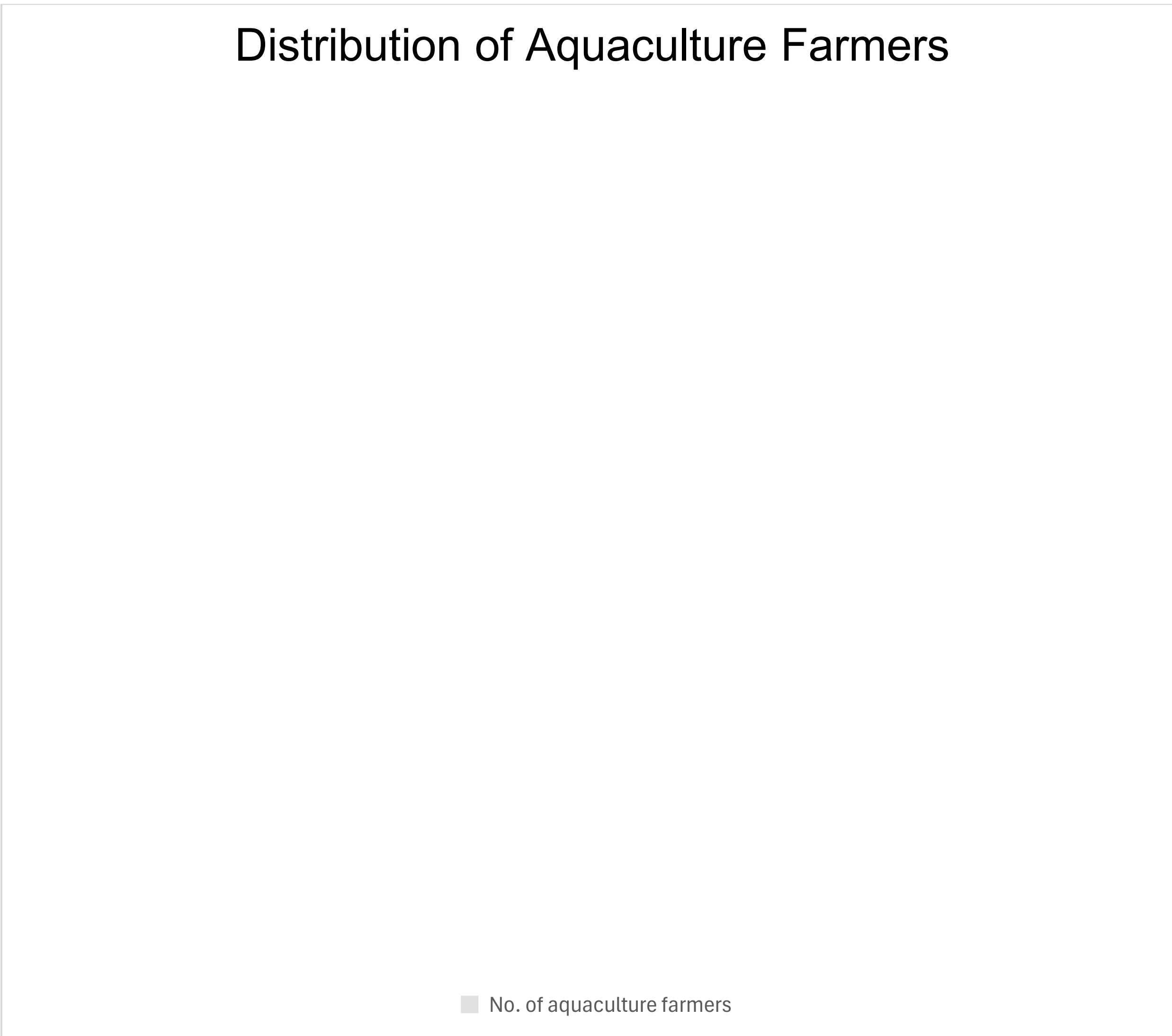


Figure 3: Distribution of aquaculture farmers in 2023

Source: Fisheries Annual Statistical Bulletin, 2024

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. 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 tons 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 tons), farmed fish production in the country would need to reach 150,000 tons 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.

1.2. Study Objectives

Agricultural development plans usually are ambitious with a long list of unaffordable, non-actionable, policy and public investment recommendations that focus on agriculture rather than agriculture-food systems and have limited overall context of market dynamics, private sector needs at ground level and potential impacts. These have resulted in plans that rely heavily on public spending and, therefore, larger requests for external financing and donor support. Prior approaches or initiatives to prioritize agricultural policy focus almost exclusively on the agricultural sector and/or improving farmers' access to local output markets. Considerable effort and resources have been directed towards assisting Ministries of Agriculture in aligning investments with strategic objectives.

The Policy Prioritisation through Value Chain analysis (PPVC) approach is a replicable, market-led, evidence-driven approach for prioritising policies and investments. This methodology was developed by the Bureau for Food and Agricultural Policy (BFAP) and the International Food Policy Research Institute (IFPRI) to evaluate which public policies, investments, and specific value chains would be most cost-effective at promoting inclusive agricultural transformation.

The PPVC approach is unique in that it provides a consistent analytical framework that consolidates spatial information about on-farm profitability, competitiveness and investment costs with off-farm analysis of projected market opportunities and assessments of downstream impacts and supporting policies within the broader agri-food system (AFS) and national economy. The PPVC approach aims to enable measurable progress in key growth and development criteria across key sectors and selected value chains, both for the public sector and as applicable private sector partnerships. Its core objectives are threefold:

- Assist governments with evidence-based analysis to adequately prioritise their policies and investments
- 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.

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 focused on value chain specific priorities. Under the various phases, the approach combines several qualitative and quantitative assessments. Figure 4 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.

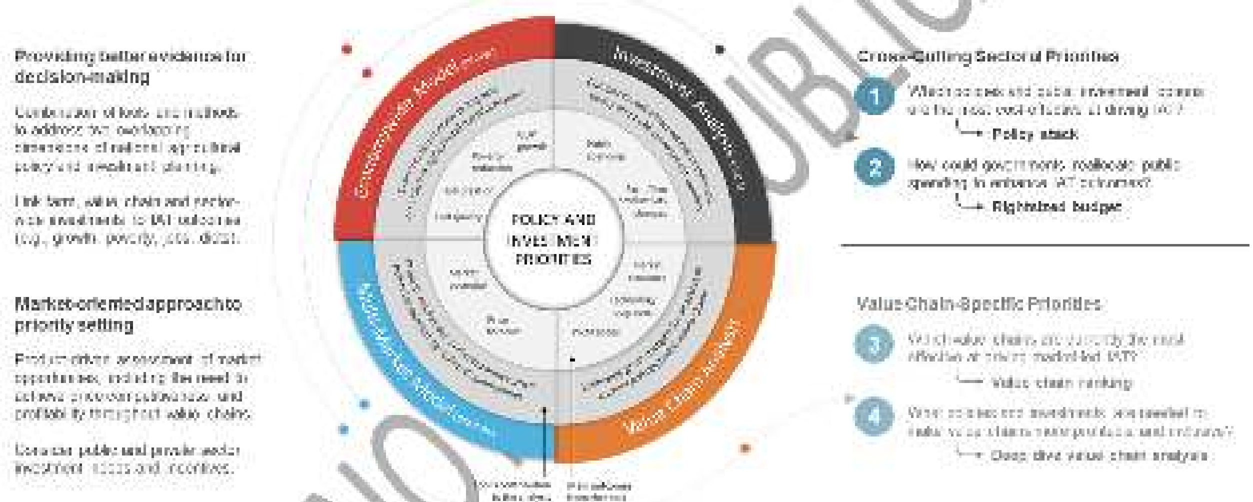


Figure 4: Overview of the tools utilised in the PPVC approach.

2. Data and Methodology

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

i. a multi-market model (BFAP/ReNAPRI PE);

ii. an Integrated Value Information System (IVIS);
iii. an economy-wide model (RIAPA-AIDA); and
iv. a 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 product flows and provides gross margins at various chain points 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 economy-wide 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 adopt 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 determines where value chains should best be located in a country, and the PE model assesses impacts on agricultural production and prices. RIAPA captures the whole economy, including agricultural and downstream subsectors, and how these combine to form a country's agri-food system (AFS).

2.1. 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.

2.2. 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 several years. Initially starting with an ad hoc combination of country and commodity coverage derived from specific research requests for forward-looking analysis in the region, the first comprehensive structure for grains and oilseeds in eight countries was established in 2012. Over time, the model has been used in various research projects and expanded to the point where it now covers twelve countries, with commodity coverage in each country ranging from one to fifteen. 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, so scenarios that impact the livestock sector spill over into grains and vice versa.

The multi-market model is a dynamic, recursive partial equilibrium framework grounded in balance sheet principles to establish equilibrium, where total supply (production, imports, and stocks) equals total demand (consumption, exports, and ending stock) for any given product. This approach, combined with market price analysis, serves as the backbone for in-depth market analysis that underpins the market-led strategy of this project. The strengths of the partial equilibrium framework lie in its capability to capture intricate market and policy details that closely reflect the situation for specific commodities. This also facilitates detailed scenario analysis when alterations occur in any of the existing variables or relationships.

Model specification generally relies on widely accepted structures and specifications of supply and demand, with prices determined by a combination of import or export parity and domestic supply and demand dynamics, depending on the market conditions for each commodity. In commodities such as maize, where regional trade dynamics are significant, the model also incorporates trade and pricing relationships within the region, as captured in an innovative trade specification detailed in Davids, Meyer, and Westhoff (2018). The modelling framework maintains consistency in supply and demand relationships and can illustrate the price impacts of alternative scenarios, as well as a dynamic response of supply and demand over time.

Parameterisation relies on a combination of econometric estimation and elasticity assumptions derived from literature review, theoretical consistency, and specialist judgement. The model is calibrated using historical data, with the period depending on data availability and consistency. For most commodities, the calibration period spans from 2005 to 2019, but data limitations led to a calibration period of 2012 to 2019 for others.

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

2.3. 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 divides the Kenyan economy into 86 sectors (half within the agri-food system) and separates 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 it is 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 within these different markets. Producers seek to maximize profits, and consumers aim to maximize utility (e.g., consumption). RIAPA, therefore, provides a comprehensive picture of the workings of the Kenyan economy while ensuring that macroeconomic consistency and resource constraints are respected.

Finally, the economy-wide model is connected 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 construct the CGE model's social accounting matrix (SAM) and 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) and other international sources, including the IMF (i.e., balance of payments and government financial statistics).

The RIAPA model simulates 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. In each value chain scenario, total agricultural GDP is projected to be one percent higher in 2030 compared to the "business-as-usual" baseline scenario. Expanding farm production increases the supply of raw agricultural products for downstream processing activities and generates demand for trade and transport services. Agricultural subsectors vary in size, and to achieve the same absolute increase in total agricultural value added (i.e., GDP), smaller value chains must expand more rapidly than larger ones. Smaller subsectors require larger productivity gains to match the impacts of larger subsectors. While such rapid growth for these smaller subsectors may be challenging to achieve, targeting the same absolute increase in agricultural GDP allows for comparisons across value chain growth scenarios.

2.4. Value Chain Analysis

The value chain analysis encompasses the entire deep dive process, integrating 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 detailed view of all products and actors, along with 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 facilitated by engaging industry specialists and private sector actors with local and international knowledge and expertise.

3. Assessment of current state

Figure 5 presents a schematic of Kenya's fish value chain. In 2023, an estimated 80% of Kenya's local fish production came from wild capture, with 69% of the 90% coming from freshwater capture, mainly in Lake Victoria (Lake Victoria accounted for 78% of freshwater capture). The aquaculture industry contributed an estimated 32 000 MT (20%) in 2023, produced in ponds and in cages.

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.

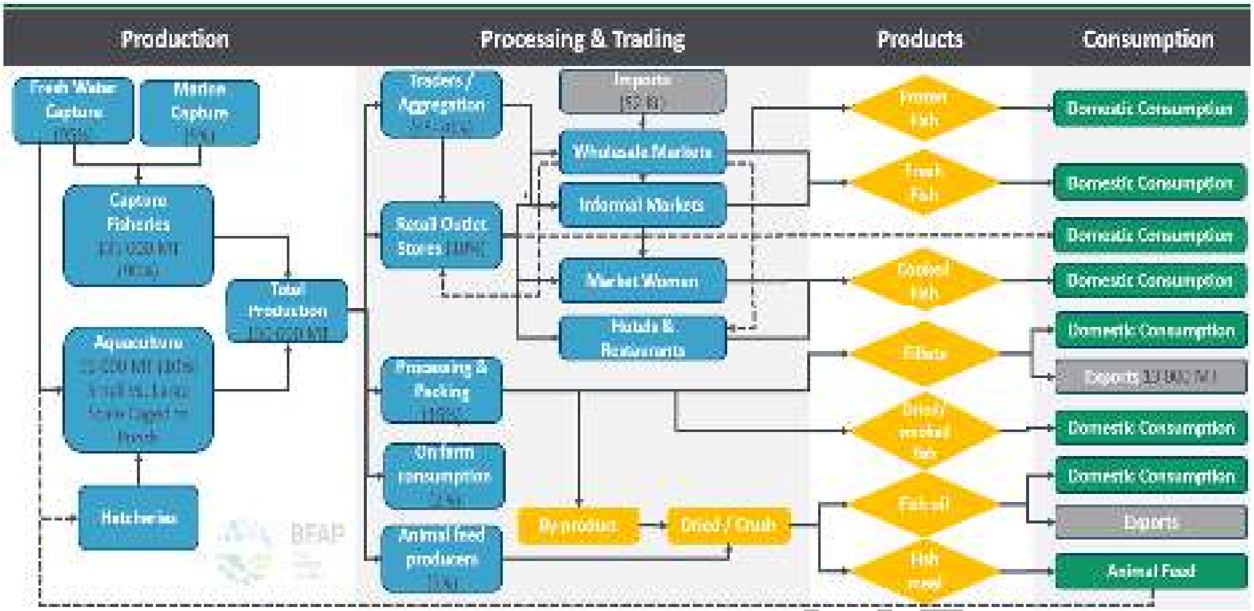


Figure 5: Kenya fish value chain with 2023 volumes and percentage shares

Source: PPVC Value Chain Analysis using data from KFS, 2024

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 focuses 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 focused 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.

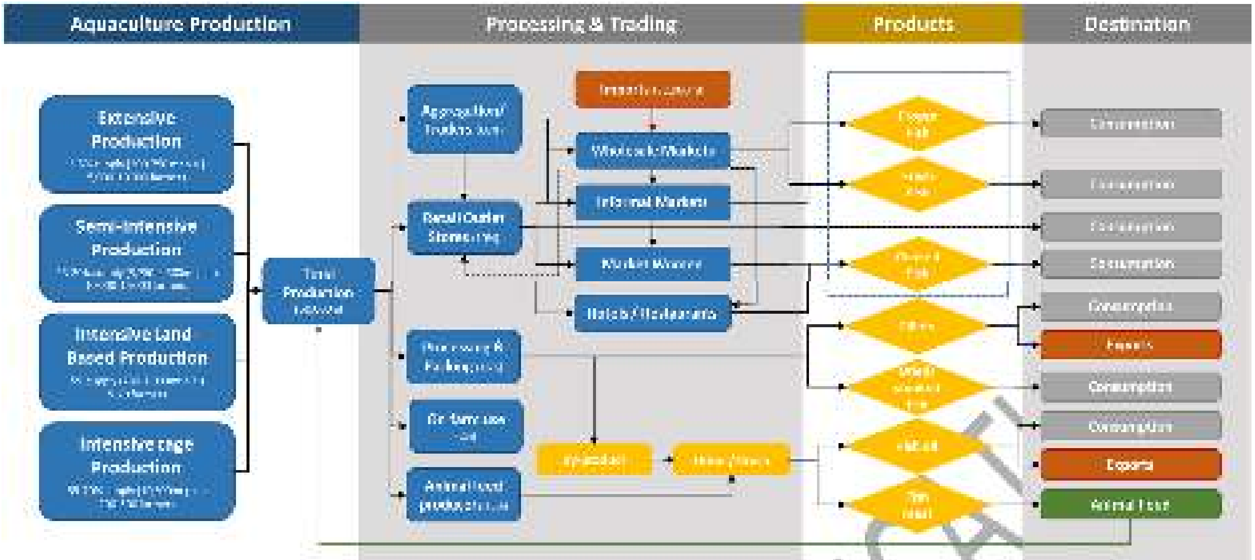


Figure 6: Kenya fish value chain with 2018 volumes and percentage shares

Source: PPVC Value Chain Analysis

3.1. Aquaculture production systems

Aquaculture production systems in Kenya can be categorized into extensive, semi-intensive, and intensive, with the intensive category further divided into land-based aerated ponds or recirculating aquaculture systems and lake-based cage systems. More than 90% of farmers practise semi-intensive fish farming, while only 3% use the intensive system due to the high cost of electricity and the lack of affordable quality feeds (Opiyo et al., 2018). In the 15 counties where ABDP is being implemented, most farmers engage in subsistence (56%), semi-commercial (31%) and commercial (13%) fish farming. The leading counties in the 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 study, aquaculture production has been grouped into two main freshwater aquaculture production systems summarised below.

3.1.1. Pond aquaculture production

This includes extensive and semi-intensive production systems. 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.

Semi-intensive production is the most common aquaculture system in Kenya, characterised by a low-feed input system, where farmers utilise earthen, liner, or concrete ponds, allowing fish to be reared in a natural environment. However, both chemical and organic fertilizers are added to the ponds to enhance the growth of natural feed. Supplementary feeding is conducted to improve productivity, with feeds sourced from on-farm formulation or purchased from cottage industries and large manufacturers/importers of fish feed. Production from this system ranges from 1,000 to 2,500 kg per hectare per year (Ngugi et al., 2007). The primary advantage of pond farming is its focus on food security and nutrition. However, farmers with medium and low commercialised ponds often resort to using cheap, poor-quality homemade fish feed and feed intended for other livestock (e.g., poultry and pigs). This leads to feed inefficiencies, which compromise fish growth and result in feed wastage, nutritional diseases in fish, and water pollution in the ponds, thereby increasing food safety risks (Opiyo et al., 2018; Obwanga et al., 2020).

3.1.2. Cage aquaculture production

Cage fishing has been practised in Lake Victoria since 2013, where production relies entirely on purchased feeds rather than natural ones. It is currently practised in five riparian counties- Migori, Siaya, Homa Bay, Busia, and Kisumu- with the highest number of cages located in Siaya County. It is estimated that Lake Victoria currently hosts about 4, 000 cages of varying sizes, primarily measuring 2 by 2 by 2 square metres, owned by around 60 different individuals. Most of the cages are privately owned (62%), while the remainder is collectively owned (Njiru and Aura, 2019). Cage farming holds significant potential to boost aquaculture production and foster economic growth in the Lake Victoria region. This is attributed to its very high stocking density compared to conventional fishing, lower investment requirements per unit area , use of existing water bodies that reduces demands on land, and reduced susceptibility to drought. Furthermore, the ease of relocating cages from one site to another enhances accessibility for operational tasks such as feeding and cleaning the nets (Njiru and

Aura, 2019). Despite its potential, it has been acknowledged that a balance between cage culture and capture fisheries is essential to ensure the sustainability of fishery resources in the lake. In the long term, cage farming may result in environmental challenges, such as the release of nutrients from fish feed and excrement, leading to alterations in the ecosystem. Thus, proper regulations on cage farming and enforcement of existing guidelines by the East African Community are necessary (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 the prospects for cage farming are hampered by the fact that it is growing faster than the governance mechanisms can evolve, due to uncoordinated policies and regulations, as well as confusion over management and regulation following devolution. Another key problem is the lack of financial and human resources. To address these challenges, Njiru et al. (2018) suggested the need for an effective policy framework and the mapping of the lake based on resource use to ensure better management and regulation of breeding areas and cages, while reducing conflict among users, fish farmers, and fishermen.

Cage fish farming has been practised in Homa Bay County since 2015, when aquaculture farmers collaborated with the Beach Management Units to gain permission to farm in Lake Victoria waters. At that time, this was a new technology, and farmers initiated their activities in the lake without general guidelines as established by the Fisheries Management and Development Act of 2016. This Act aims to conserve, manage, and develop fisheries and other aquatic resources to enhance the livelihoods of communities dependent on the water body and surrounding resources. In general, anyone wishing to engage in cage fish farming must obtain a National Environmental Management Authority (NEMA) certificate, a cage fish farming permit from the Kenya Fisheries Service, and a concession or allotment letter from the Ministry of Lands and Physical Planning specifying the area for placing the cages. Although the Fisheries Management and Development Act of 2016 had not yet come into force when farmers in Homa Bay began cage farming, it clearly stated that an environmental and social impact assessment is required before a permit can be issued. Even after the Act commenced in September 2016, the fisheries department faced the dilemma of whether it is reasonable to burden a farmer with few cages with the requirement to acquire all the necessary documents.

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

Due to failure to follow guidelines, some fish cages have been placed in the lake contrary to maritime laws, posing an environmental hazard to marine life. Fish cages interfere with the lake’s ecosystem because they have been positioned without any environmental impact assessment. Many aquaculture farmers in Homa Bay and Siaya counties engaging in cage fishing have contributed to the dwindling fish stocks. The increase in cages has led to a reduction in captured fish as they encroach on breeding areas. Some cages are also located on transport routes. There are concerns that continuous unregulated placement of cages in the lake may soon introduce non-approved species of fish.

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

3.2. Fish markets and prices

Large traders who purchase substantial volumes of fish primarily target large urban markets. Demand often exceeds what traders can supply in cities and towns like Kisumu, Nakuru, Nairobi, Eldoret, and Mombasa, allowing bulk buyers to negotiate price discounts. They are typically looking for a steady supply of fish at prices they can sustain (Obwanga et al., 2020). This arrangement largely benefits farms supplying institutional clients interested in plate-sized fish, ideal for restaurants.

Farmers producing fish under the semi-intensive system sell at retail prices to local household consumers. Small-scale pond farmers can also sell limited amounts of fish over an extended period until their entire stock is depleted. Small-scale farmers in Western Kenya add value immediately after harvesting by deep-frying, as a preservation method that also satisfies the needs of customers in highly populated urban areas. In highly intensive systems, the costs of maintaining large volumes of mature fish are significant, leading to the disposal of entire batches at once, sometimes at relatively lower prices. Farmers who sell their full stock at once or in high volumes typically 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 assessments by traders or Industrial Fish Processor (IFP) agents, who also provide storage equipment for fishermen at the landing beaches. Nile Perch intended for processing must meet the processor’s criteria, such as size and freshness. The remaining fish is sold to other participants in the chain, including wholesalers, retailers, and even consumers. Processors, wholesale traders, and transporters obtain supplies from the landing sites every morning. Some of these traders and processors own fishing gear and employ fishermen who are paid daily wages.

For aquaculture, wholesale traders receive information about specific harvesting days when fish farmers in a particular area agree to sell their fish. Harvesting takes place in the evening, and the fish are placed in refrigerators or coolers before being picked up by trucks equipped with cold storage facilities.

To gather insights on the nature of fish markets and the prices received, key stakeholders were interviewed at major fish markets and landing sites in Nairobi, Siaya, Kisumu, and Homa Bay, which serve as the main points of sale.

3.3. Major inputs

Across the various aquaculture production systems, the major contributors to the cost of production are feed and fingerlings. However, feeds are the most significant cost compent in intensive and semi-intensive production systems. In some systems, these are procured independently, while in others they are integrated into a single producer; however, 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. Currently, there are 24 approved feed suppliers, six of which import feed. However, the growth of the feed sector is hampered by weak regulation, resulting in poor-quality feeds (Obwanga et al., 2020). The main raw materials and ingredients used for fish feed processing include 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 include distributors of high-quality imported feeds such as Samaki Express E.A. Limited, which is well known among most fingerling producers. Fish feeds from Unga Ltd are highly regarded for their quality, which also makes them expensive. Other established livestock feed processors acknowledge that products from Unga Feeds are superior in quality, and since they cannot match this quality, they use pricing as leverage to market their products. Quality constraints among many domestic feed producers are also a frequently noted reason for opting to rely on imported feed instead.

Raw materials represent a major cost component in feed production, accounting for up to 70% of the final price farmers pay. Production and marketing costs make up the remaining 30%. In this context, the high prices of essential raw materials pose a significant barrier to developing a competitive animal feed industry in Kenya. The primary challenges associated with animal feed manufacturing in Kenya include:

- High aflatoxin levels: Some feeds are rejected due to high aflatoxin levels, which in some cases have exceeded 10 parts per billion. • Overreliance on imported raw materials: The country does not produce sufficient amounts of oil crops and maize.
- Low yields: These result from poor crop and soil management practices in producing crops that serve as raw materials for feed processing.

- Compromised feed quality: Emerging small enterprises engaged in local feed formulation face challenges. Proper machinery for feed mixing and formulation is lacking for most small enterprises. They often use the most affordable and available raw materials, resulting in some locally formulated feeds failing to provide balanced diets for fish, leading to nutritional deficiencies and poor growth.
- Low crude protein levels: There are insufficient levels of crude protein in the fish feed raw materials supplied to feed processors.

Kenya has a significant deficit of raw materials for livestock feeds, primarily because maize competes with human food consumption. Uganda has gradually become a more efficient producer in the dairy and poultry sectors due to the availability of quality raw materials such as maize, sunflower cake, and cottonseed cake. Among East African countries, Kenya has the largest capacity to utilize maize bran, sunflower cake, and cottonseed cake, which are available at a lower cost from Tanzania and Uganda. Tanzania and Uganda benefit from a more relaxed tax regime compared to Kenya, further encouraging imports from these two nations.

Some raw materials are available locally in Kenya, though at a higher cost. However, the main protein sources, including soybean meal, sunflower cake, and cottonseed, are imported. The costs and sources of raw materials are as presented in the document but can fluctuate considerably more than the specified range indicates.

Table 1: 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 various hatcheries across the county, owned by both government and private sectors. Most independent hatcheries are large and widely distribute fingerlings. Production systems include earthen ponds, lined ponds, and advanced recirculating systems. Effective management of brood stock is essential, often using imported feed for quality. Hatcheries typically sell mixed or monosex fingerlings. Monosex fingerlings, produced with additional hormone treatments, are pricier but yield superior growth. Fingerlings are managed until ready for transfer to cages or ponds, with a complete Tilapia fingerling cycle taking about two months. Fertilised egg collection starts after 10 days and lasts no longer than a month. Eggs are incubated in controlled environments for 12 to 24 hours until hatching. The fry are then placed in separate tanks and fed hormone-treated powder feeds for 21 to 28 days, depending on temperature; this can be shortened to 21 days in warmer conditions. Mixed-sex fry do not receive hormones. Key costs in fingerling production also 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. 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. Value chain analysis on the improved state

4.1. Challenges in the aquaculture sector in Kenya

Overall, aquaculture production in Kenya faces several challenges, including high prices for commercial fish feeds, poor feed quality, decreasing Nile Perch catches in Kenyan waters, a shortage of storage facilities, an unreliable power supply affecting the ability to preserve fish, conflicts between farmers and fishermen, occasional bad weather creating dangerous waves in the lake that damage fishing equipment and hinder fishermen from monitoring their cages, and a lack of capital necessary to initiate cage farming.

Among the numerous issues, one of the greatest challenges is the inability to compete with imported products, primarily due to the high cost of feed, which is the largest contributor to elevated production costs. Figure 7. compares fish prices at various points in the value chain in Kenya (grey) to production costs in semi-intensive and intensive systems (blue), as well as the cost of imported fish from multiple sources (red). Clearly, in both semi and fully intensive systems, production costs are comparable to, or exceed, the cost of imported Tilapia – depending on the size of the imported fish. This analysis does not factor in any profits for the producer and is a significant factor contributing to the increase in import volumes. lumes.

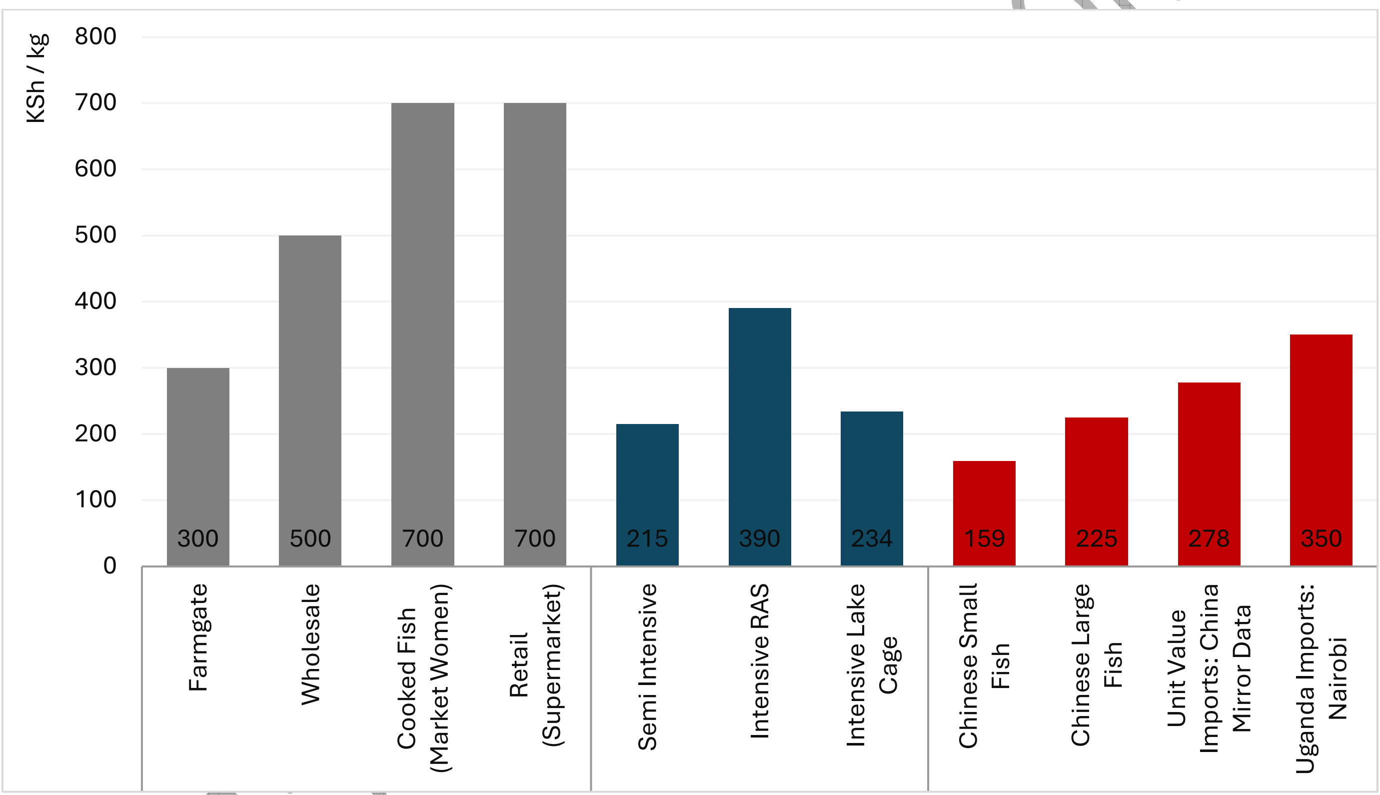


Figure 7: Comparison of local prices, production costs and import prices (KSh/kg)

As part of the deep dive analysis, an evaluation of producer margins indicated that, across all three systems, feed constituted the largest single 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 over 90% in intensive cage-based systems. Within the RAS system, the lower share of feed is attributed to additional costs such as electricity, which also introduces extra risks due to inconsistent supply. The increased total costs associated with this system imply that producers need a significant premium for the fish to achieve a positive margin when producing fish for the market rather than fingerlings for farmers.

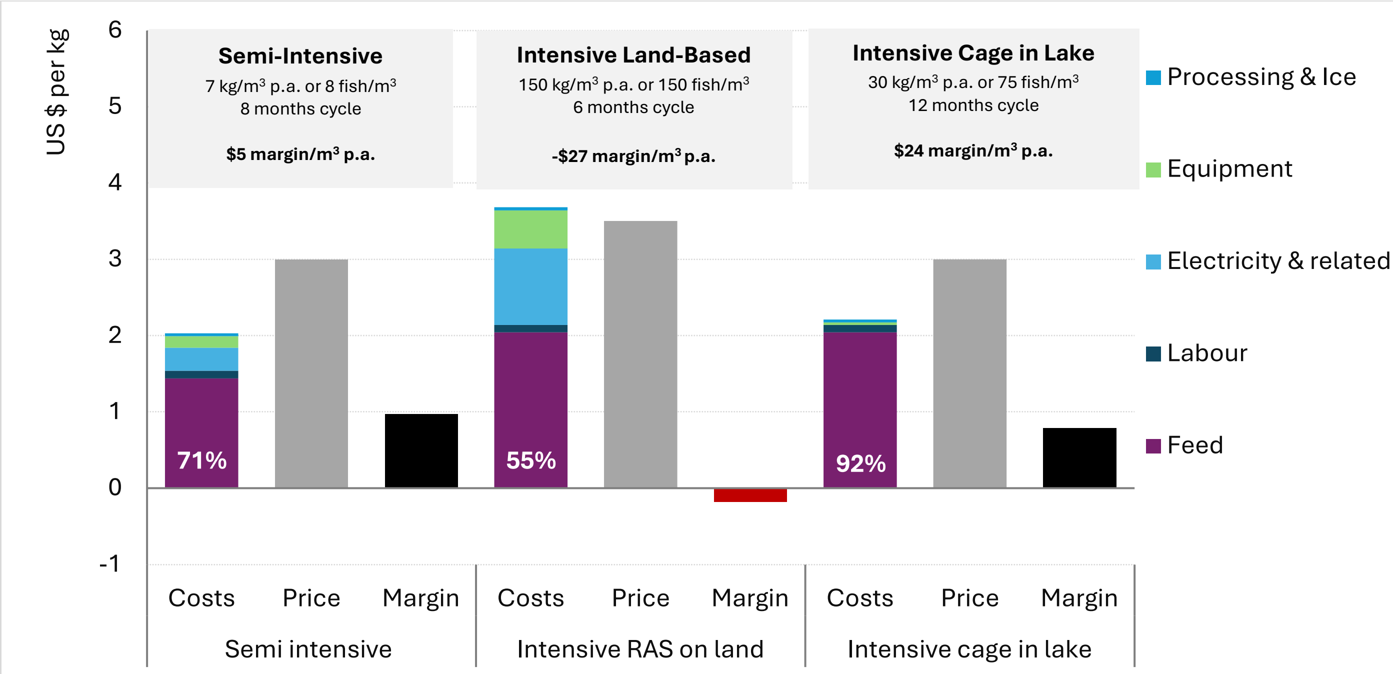


Figure 8: Breakdown of producer costs & estimated gross margins (US$/kg)

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 2.

Table 2: Import tariffs applied to selected feed products in 2025

	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, 2025

The second issue 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 from Egypt or Zambia. While this yields more consistent performance, high transportation rates, combined with administrative and logistical fees, all add to the cost and contribute to the challenge of expensive feed rations. Furthermore, Table 3 indicates that despite these costs, domestically produced feed remains more expensive than imported feeds. Quality will need to improve to match imported products to increase the uptake of domestically produced feed, and prices must become more competitive.

Table 3: 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; it stems from a lack of raw material production. The country is a net importer of most major raw materials required for animal feed manufacturing, including maize, soybean meal, and fish meal. This increases prices, as raw materials are priced at import parity levels. Raw maize and soybean meal can be obtained at significantly lower costs in regions such as the USA, the Black Sea region, or South America. However, transport costs (sea freight and inland), port and handling fees, and tariffs all contribute to these import parity levels. Additionally, both soybean meal and maize sourced from outside the East African Community are subject to significant tariffs of 10% and 50%, respectively. In the case of maize, this is further compounded by the premium payable for non-GM maize. Although non-GM maize can be sourced duty-free in Uganda or Tanzania, inland transportation rates remain a challenge and increase costs. costs.

In the case of fishmeal, an important protein source in fish feed, domestic production is limited, firstly because Omena is predominantly for human consumption, secondly because of regulation 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.

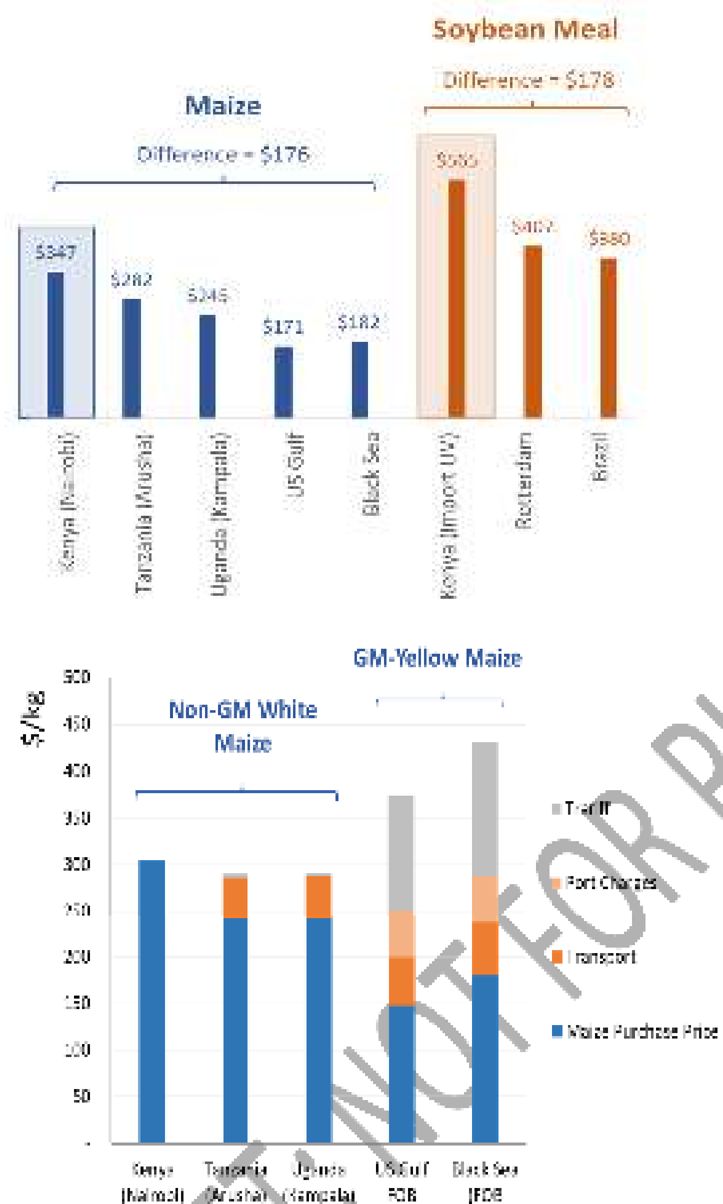


Figure 9: Comparison of raw material costs sourced at different destinations

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, removing 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. Removing the current 4.5% administrative fee on imports will reduce costs, improve the competitiveness of fish production and initiate expansion, broadening 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 the 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 and amongst extension staff.

Establishing a high-quality, competitive domestic feed industry in the medium term 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 incentivize 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.

5. 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 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 and the gross margin impacts are introduced into IFPRI's general equilibrium RIAPA model, detailed in Box 3, which simulates the economy-wide 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 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 the 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 are 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) Remove 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.

5.1. Gross margin impact

Figure 10 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 10 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.

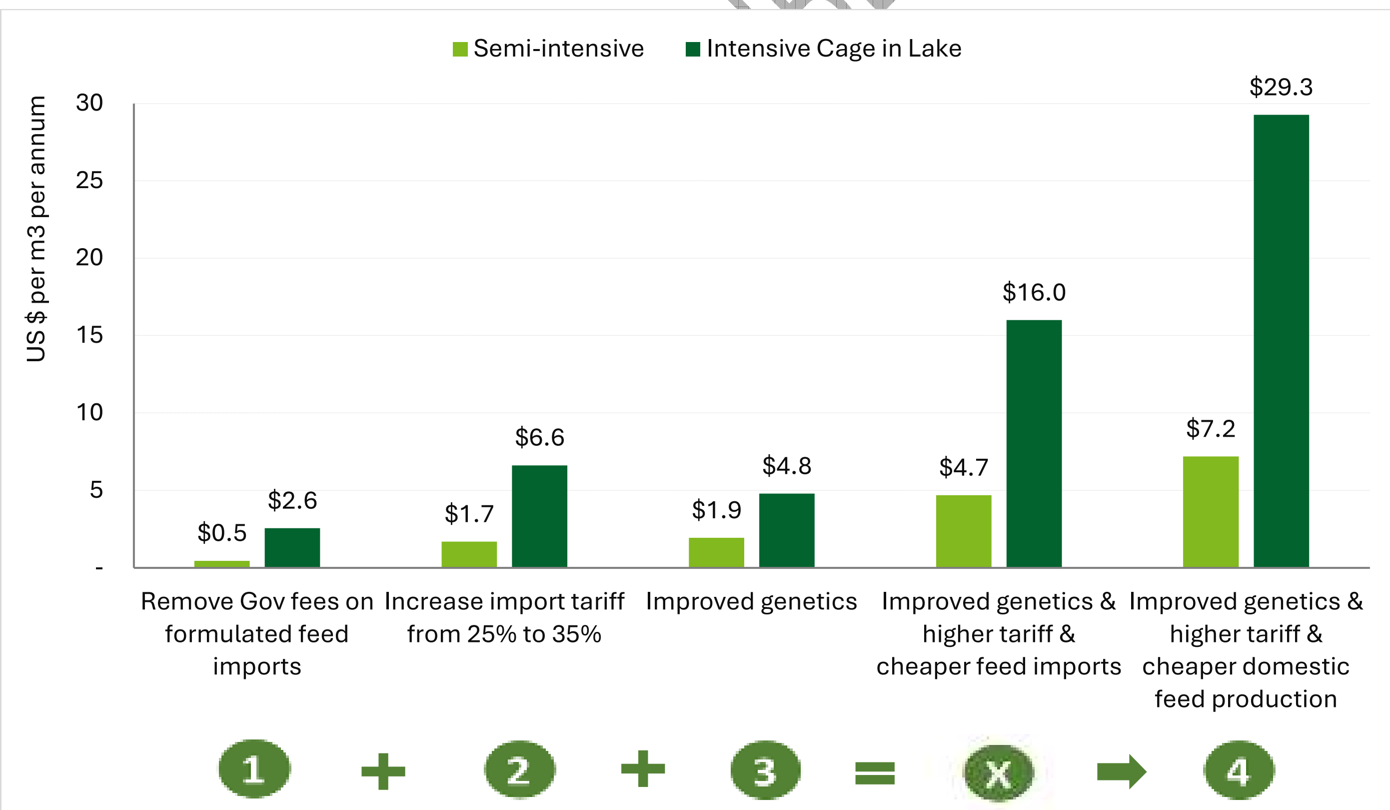


Figure 10: Change in gross margin from under various scenarios (US $ per m3 per annum)

Source: PPVC value chain analysis

5.2. Market impact: Partial equilibrium market model simulations

Figure 11 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 tons 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 tons 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.

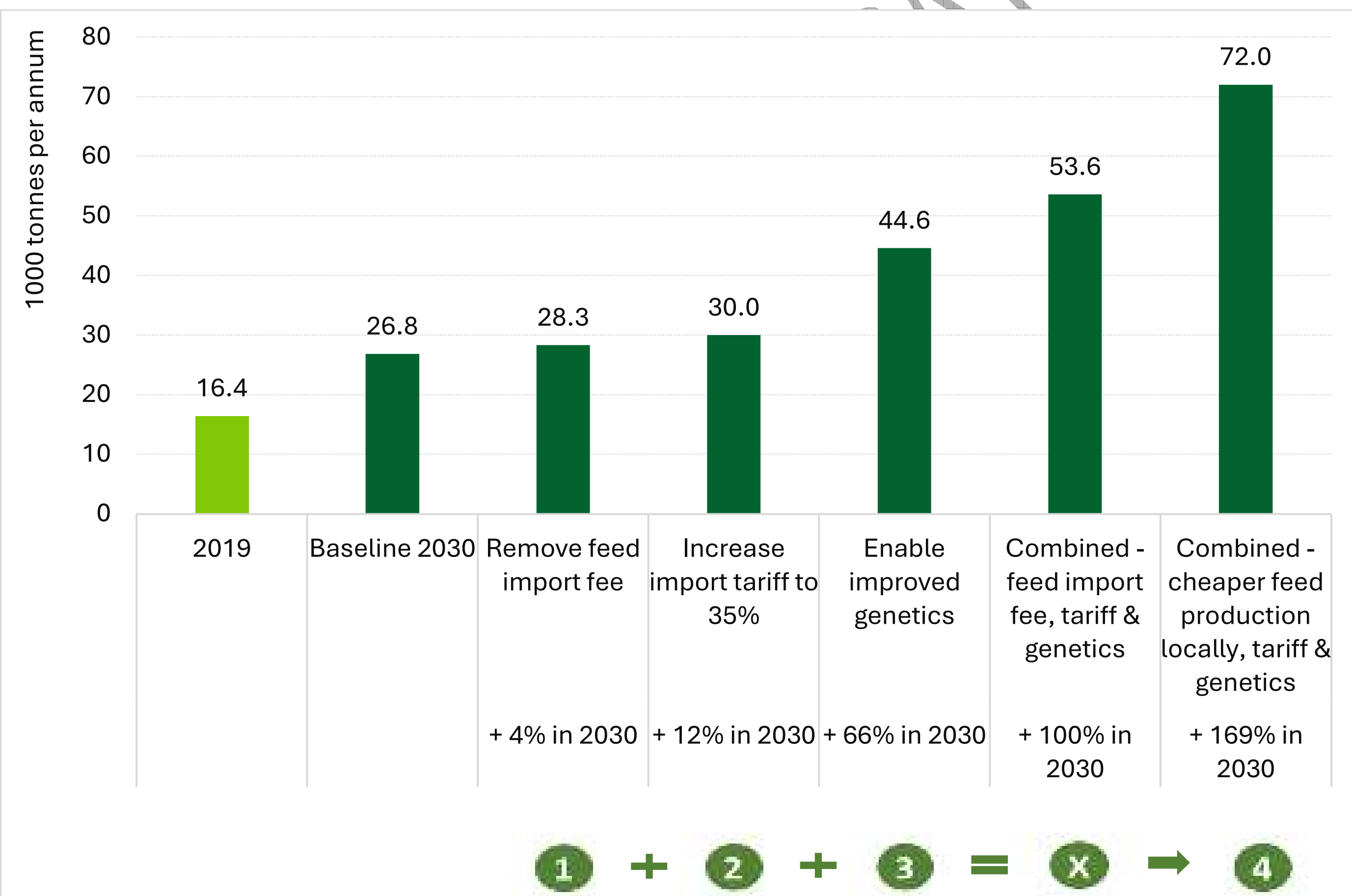


Figure 11: Aquaculture production in 2019 compared to the baseline projection for 2030 and the various scenarios

Source: BFAP Africa multi-market PE model

Figure 12 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.

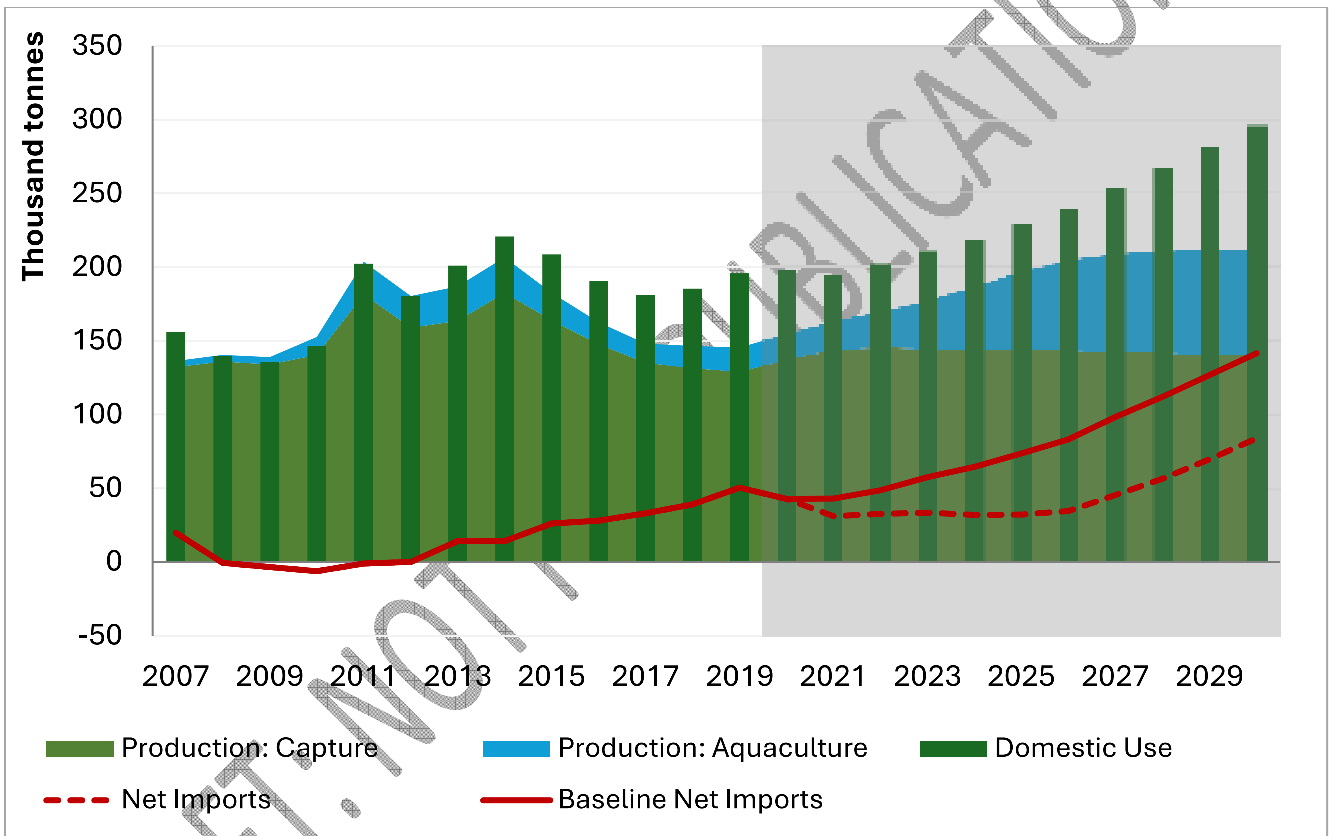


Figure 12: Fish production, consumption and trade in Kenya under the complete improved state (Scenario 4)

Source: BFAP Africa multi-market PE model

5.3. Economy wide impact: RIAPA General Equilibrium simulations

Figure 13 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 13 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.

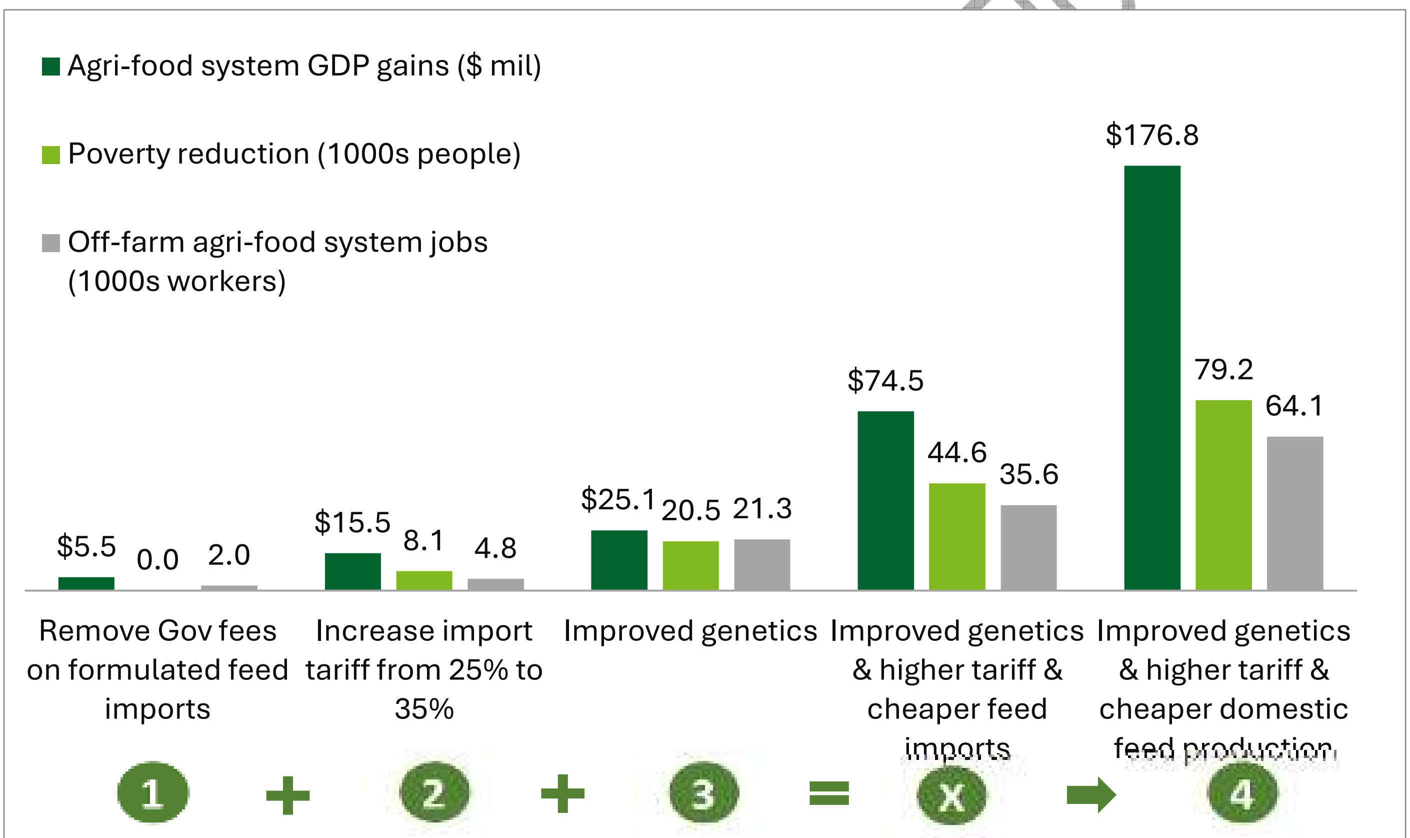


Figure 13: Impacts of various interventions on GDP, employment and Poverty by 2030

Source: IFPRI RIAPA Kenya economy wide model

6. Tracking implementation of reforms

6.1. Government interventions on feed costs

After the deep-dive analysis, recommendations were made, and stakeholders in the animal feed industry lobbied the government to implement measures to reduce feed costs. The government implemented duty waivers on raw materials for animal feed; however, the waiver maintained a caveat that the raw materials must be non-GM (a stay on the ban). Five duty waivers have been implemented since 2021, with four of the waivers directly targeting raw materials for animal feed manufacturing (Table 4).

Table 4: Duty waivers for raw materials for animal feed manufacturing

Period	Commodity waived
1st Nov 2021 – 31st Oct 2022	Yellow maize, soybean, soybean meal, sunflower cake, cotton cake, premixes
20th May 2022 – 6th Aug 2022	White maize
1st Nov 2022 – 6th Aug 2023	Yellow maize, soybean, soybean meal, sunflower cake, cotton cake, premixes
6th Aug 2023 – 7th Feb 2024	Yellow maize, soybean, soybean meal, sunflower cake, cotton cake, premixes
1st Jul 2024 - 30th Jun 2025	Yellow maize, soybean, soybean meal, sunflower cake, cotton cake, premixes

Source: Authors compilation using Kenya Gazette publications

Table 5 shows the maize imports that came in during the import waiver period. About 53% of the white maize quota was imported during the waiver period. However, the maize originated from the EAC and COMESA markets. This implies that the maize qualified to be shipped to the country without the EAC CET tariff. Therefore, the waiver from 20 May 2022 to 6 August 2022 was ineffective as no imports originated outside the EAC and COMESA markets to trigger the waiver.

Table 5: Maize imports during the duty waiver period

Waiver	**Period**	**White Maize**	**Yellow Maize**
	Quota (tons)	**540,000**	**225,950**
1	1st Nov 2021 – 31st Oct 2022	775,978	758
2	20th May 2022 – 6th Aug 2022[1]	285,205	9,226
3	1st Nov 2022 – 6th Aug 2023	315,376	45,043

[1] Waiver for white maize only.

4	6th Aug 2023 – 7th Feb 2024	125,481	58,955
5	1st Jul 2024 - 30th Jun 2025		
	Total	**1,216,835**	**104,756**
	Share of total imports	**92%**	**8%**

Source: Authors compilation using data from ITC TradeMap

During the four duty waivers from 2021 to 2024, about 105,000 tons of yellow maize were imported. This represents 46% of the quota allocated for yellow maize. Our understanding is that if the volume quota had been met in the first waiver period, the subsequent quota would have an increased allocation. The low utilization of the quota implied that the waiver for yellow maize was equally ineffective.

Similarly, the waiver to allow the importation of soybean from outside the region was ineffective. During the period the waiver was in place, although 94,360 tons were imported, only 8,038 tons or 9% of the imports qualified for the duty waiver. Therefore, the waiver was ineffective in helping local importers access global markets that would have seen them import the required volume and address the challenges in the feed industry.

Table 6: Soybean imports during the duty waiver period

Waiver	Period	Soybean meal & cake		
	Quota (tons)	**126,300**	**EAC/COMESA**	**non-EAC/COMESA**
1	1st Nov 2021 – 31st Oct 2022	59,229	59,131	97
3	1st Nov 2022 – 6th Aug 2023	24,634	24,126	507
4	6th Aug 2023 – 7th Feb 2024	10,497	3,064	7,433
5	1st Jul 2024 - 30th Jun 2025	-	-	-
	Total	**94,360**	**86,322**	**8,038**
	Share of total imports	**100%**	**91%**	**9%**

Source: Authors compilation using data from ITC TradeMap

6.2. What explains the failure of duty waiver policies?

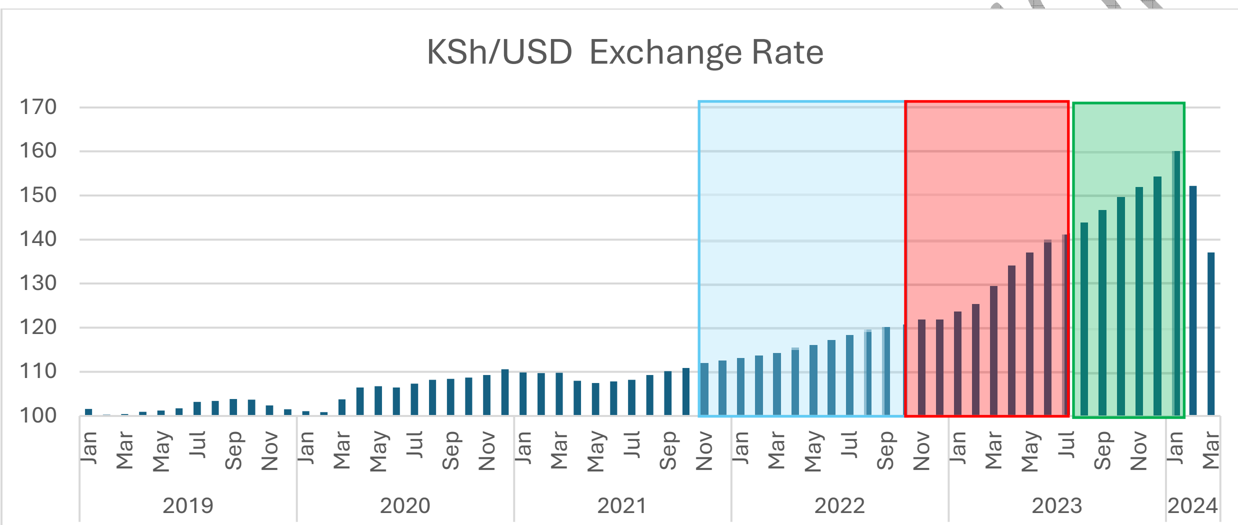
6.2.1. GM ban requirement and the Russia-Ukraine war

The government lifted the ban on GM products in 2022. However, there have been court cases challenging the waiver of the ban, and although the court threw out the challenges, appeals on the ruling have been launched, and the cases are still ongoing. This means that although we had duty waivers, importers needed to secure non-GM products. Ukraine was the most significant source of non-GM maize and soybeans. This source market was completely inaccessible after the war broke out in February 2022. Although there have been efforts to access grain from the black sea, such as the black sea grain initiative, this has prioritized grain for the humanitarian crisis, as the Horn of Africa region had a serious drought in 2021.

6.2.2. Exchange rate shock

Kenya's exchange rate deteriorated in 2022 and 2023, recording about 40% depreciation during the period. The deterioration wiped out any gain the duty waiver could have provided animal feed manufacturers in a bid to lower prices.

Figure 14: Trends in KES/USD exchange rate

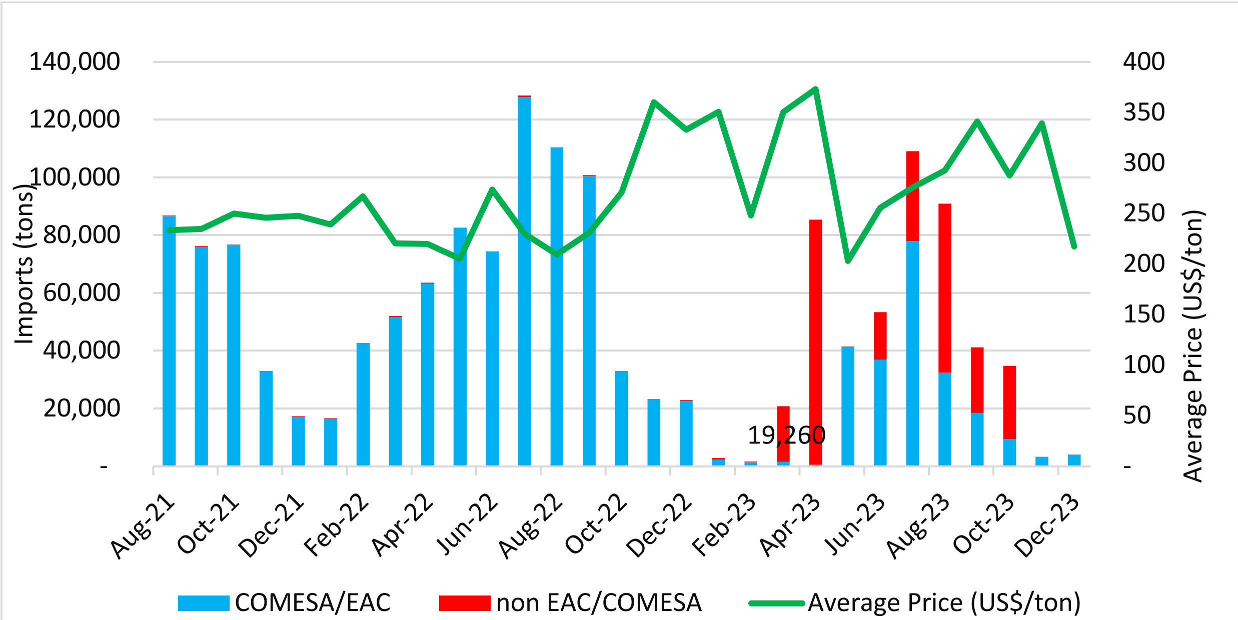


Source: Authors compilation using data from Central Bank of Kenya

6.2.3. Global market price increases

During the period when the waivers were in effect, local maize prices remained volatile and higher than global prices. In the period after the local maize harvest period, prices were stable. However, they rose during the long rains planting period. The price volatility combined with an exchange rate shock meant that importers likely faced increased exposure to market risks and likely losses and may have opted for domestic and regional markets where they could trade in local currency.

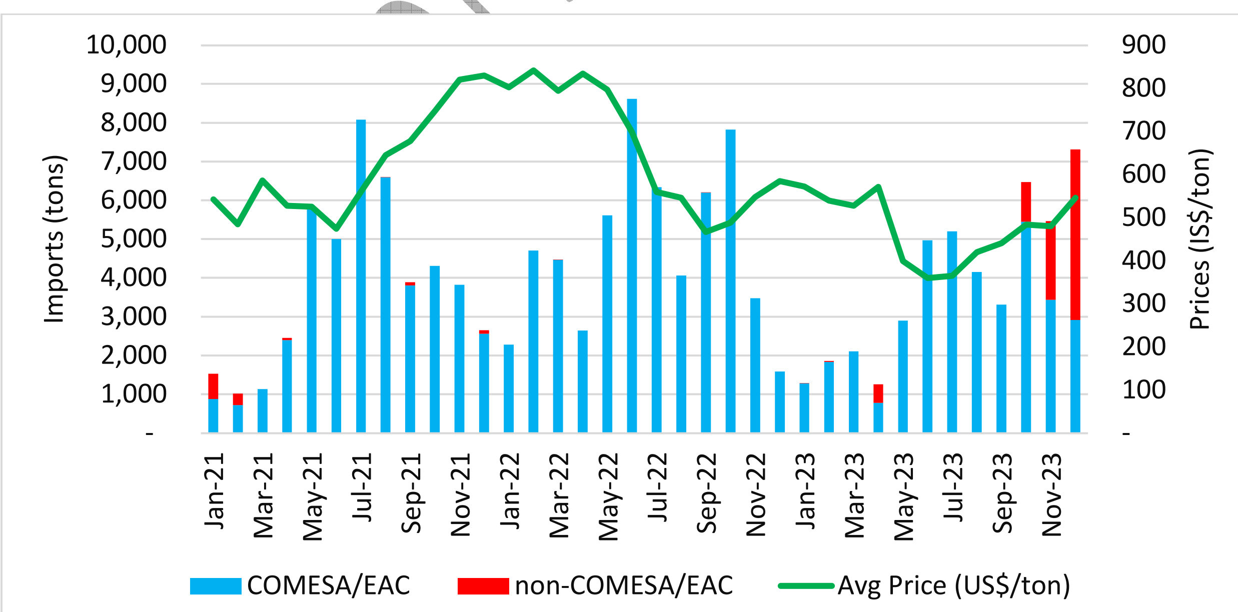
Figure 15: Trends in maize imports and average maize prices



Source: Authors compilation using data from ITC TradeMap

Soybean prices peaked following the Russian- Ukraine war. However, countries adjusted and found alternative markets, and prices eased. Nevertheless, prices started to rise again mid-2023, reaching the 2022 highs, and stabilizing at these high levels.

Figure 16: Trends in soybean imports and average soybean prices



Source: Authors compilation using data from ITC TradeMap

6.3. Policy on restricting imports

Freshwater fish production has declined in recent years following adverse weather experienced in the country, particularly two years of drought from 2021 to 2023. This mainly led to a significant drop in capture fisheries in the natural water bodies. However, cage culture has grown exponentially in the past seven years. The growth in cage culture has occurred with a simultaneous decline in imports. Imports declined following increases in tariffs, suggesting that although the volumes from capture fisheries have also declined, production from cage culture has filled the gap from capture fisheries and imports.

The government raised the import tariff from 10% to 25% to 35% and imposed an excise duty of 20% of CIF or Ksh 100,000, whichever was higher, on imported fish. These taxation policies significantly reduced fish imports from 2022 to date. Table 6 shows the trends in freshwater fish production and imports. Overall, freshwater fish production declined in 2022 and 2023 because the decline in capture fisheries and imports was more significant than the increase in cage farming.

Also, as shown in Figure 1, there is a greater incentive for increasing aquaculture production if the policy can be reoriented towards providing farmers with cheaper feed. This will lead to lower operational costs and a reduction in prices, which will trigger increases in demand while ensuring that producers remain profitable and have incentives to increase investments in fish production.

7. What can be done to unlock the potential of aquaculture production

The cost of animal feeds in Kenya is a multifaceted issue influenced by various factors, including raw material prices, import dependence, energy and transportation costs, and government policies. These costs have significant economic implications for livestock farmers, affecting their profit margins, livestock health and productivity, and market prices. Addressing these challenges requires a comprehensive approach involving enhanced local production, subsidies, innovative feed solutions, and improved infrastructure. By implementing these strategies, Kenya can stabilize feed costs and support the sustainability and growth of its vital livestock sector.

Feed sector reform is imperative to unlock the fish industry's full potential. The government must address barriers hindering access to cheaper raw materials in global markets, including lifting bans on GM products and developing supportive regulations for the importation and local production of these products.

In the short term, the government should allow the importation of semi-processed GM products and alternative raw materials such as crushed maize, Distillers Dried Grains with Solubles (DDGS), and soy cake.

Addressing high energy, transportation, and taxation costs will improve feed manufacturers' overall business environment in the medium term.

In the long term, the government should invest in research and development to utilise alternative, cost-effective raw materials like insects in feed production and bring these technologies to scale. In addition, it should incentivize the adoption of modern technologies and capacity utilization incentives to enhance efficiency in the feed sector.

7.1. What is the potential impact of allowing GM raw materials?

The analysis models the potential impacts of allowing duty-free imports of GM maize, soybeans and meals for specific use in the animal feed sector. There is a specific restriction to limit the proposed GM imports to very specific uses that don't include human consumption, and therefore, a less controversial policy choice due to the sensitivities around GM products. Furthermore, the price does not affect the small share of domestic production as it is very small, and the imports can be monitored to ensure that traders/millers do not import more than demand.

The tracking of this policy intervention includes monitoring the immediate benefit to aquaculture producers through broadening procurement options for the livestock feed industry and the potential effect on the aquaculture value chain, as well as evaluating indicators such as production and competitiveness.

7.1.1. Soybeans

Soybeans are an essential source of plant protein in livestock feeds. Soybean constitutes about 22% of the inputs for a typical fish feed ration and 28% for poultry ration. The key substitutes are sunflower meal and cottonseed cake. However, soybean cake is preferred because of its higher protein content, making it cheaper in terms of kilos of protein per dollar. Protein sources for livestock feeds are largely imported.

The price of soybean meal in recent years has remained high since the market shock in 2019 (

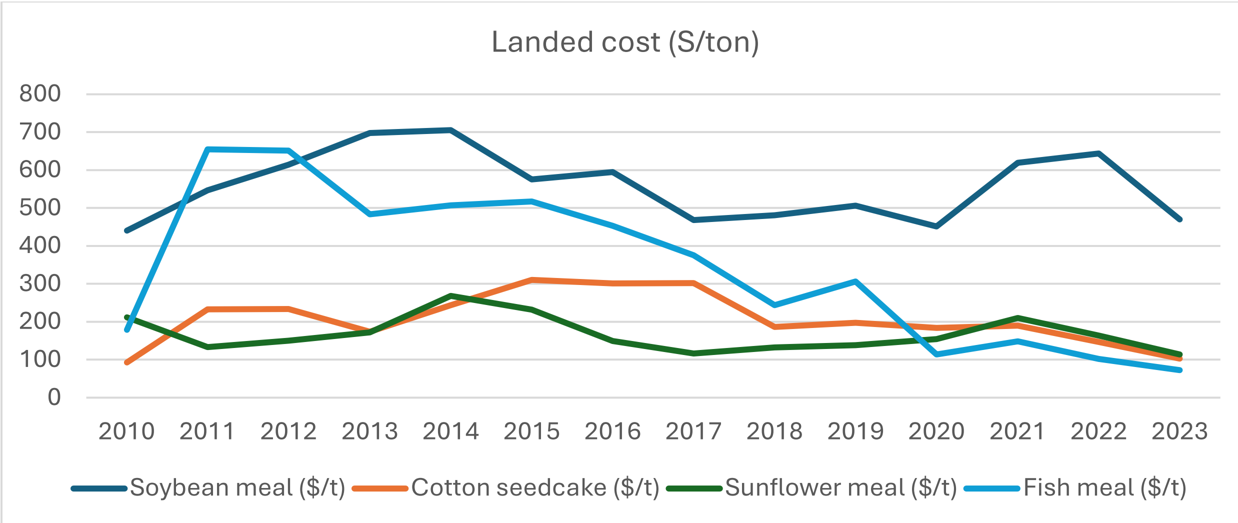


Figure **17**). The soybean meal price remained high until 2023, when it started falling. Prices for other oilcakes have remained significantly lower, with cottonseed cake and sunflower cake converging in 2023. Fishmeal prices have consistently dropped since the past decade. These raw materials are combined into a feed ration for different species.

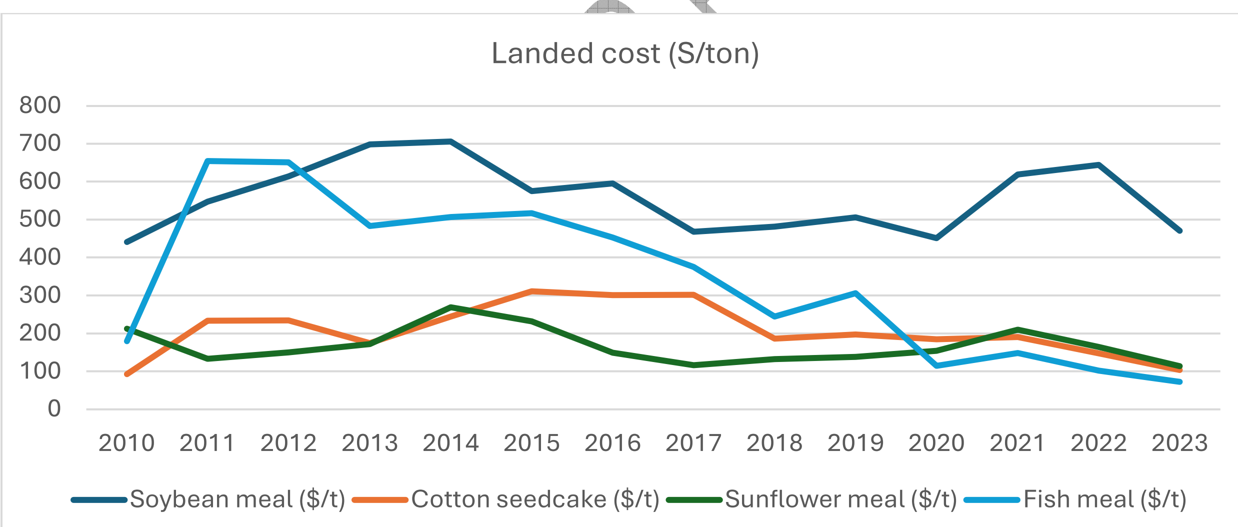


Figure 17: Landed costs for protein sources for livestock feeds

Source: Authors compilation using data from ITC TradeMap

As expected, the falling prices of sunflower meal and rising prices of soybean meal led to a significant increase in sunflower meal imported volumes, although soybean meal volumes had a mini turnaround in 2022 (Figure 18). On the other hand, fish meal import volumes have largely remained constant over the past decade.

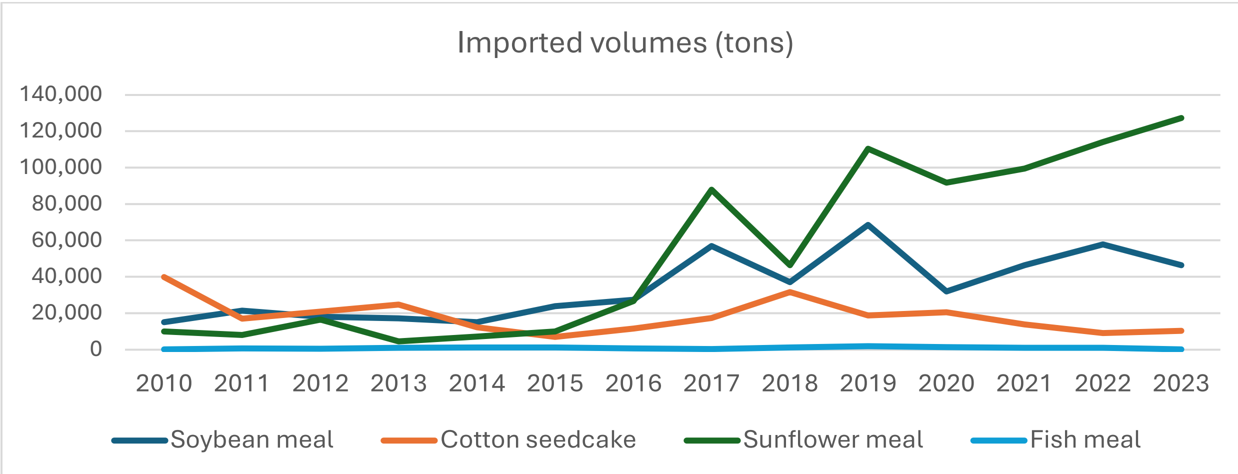
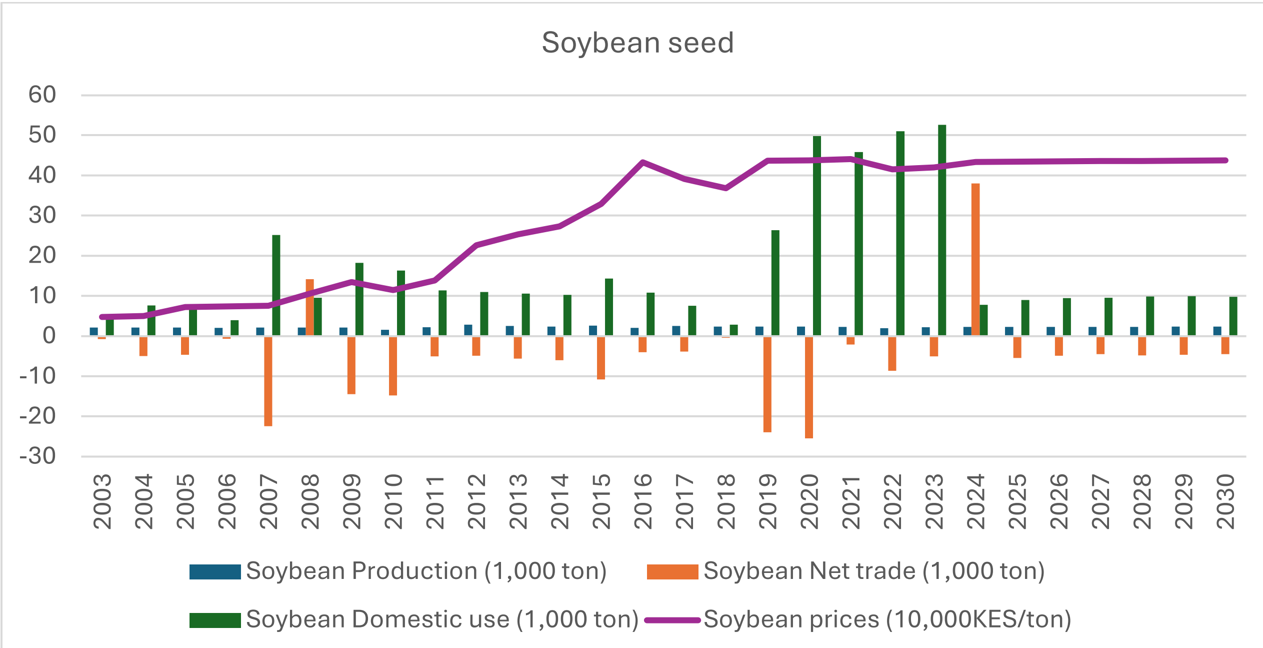


FIGURE 18: IMPORTED VOLUMES FOR MEAL CAKES FOR LIVESTOCK FEEDS

Source: Authors compilation using data from ITC TradeMap

Kenya mainly imports soybean meal as opposed to beans. This is despite the available installed capacity for processing oil seeds. Feedback from processors indicates that Kenya has an installed capacity to process upwards of 50,000 tons of seed annually. Besides, this capacity, the livestock feed industry has an installed capacity to mill 1.5 million tons annually. This is mainly because countries in the region, e.g. Zambia and Malawi, impose restrictions on beans exports. Kennya has a spike soybean seed imports from 2019 to 2023. Duty waivers drove this and reexports as the market adjusted (Figure 19). Soybean meal imports dippers in due to the pandemic shock that slowed demand and demand has recovered by 2023.



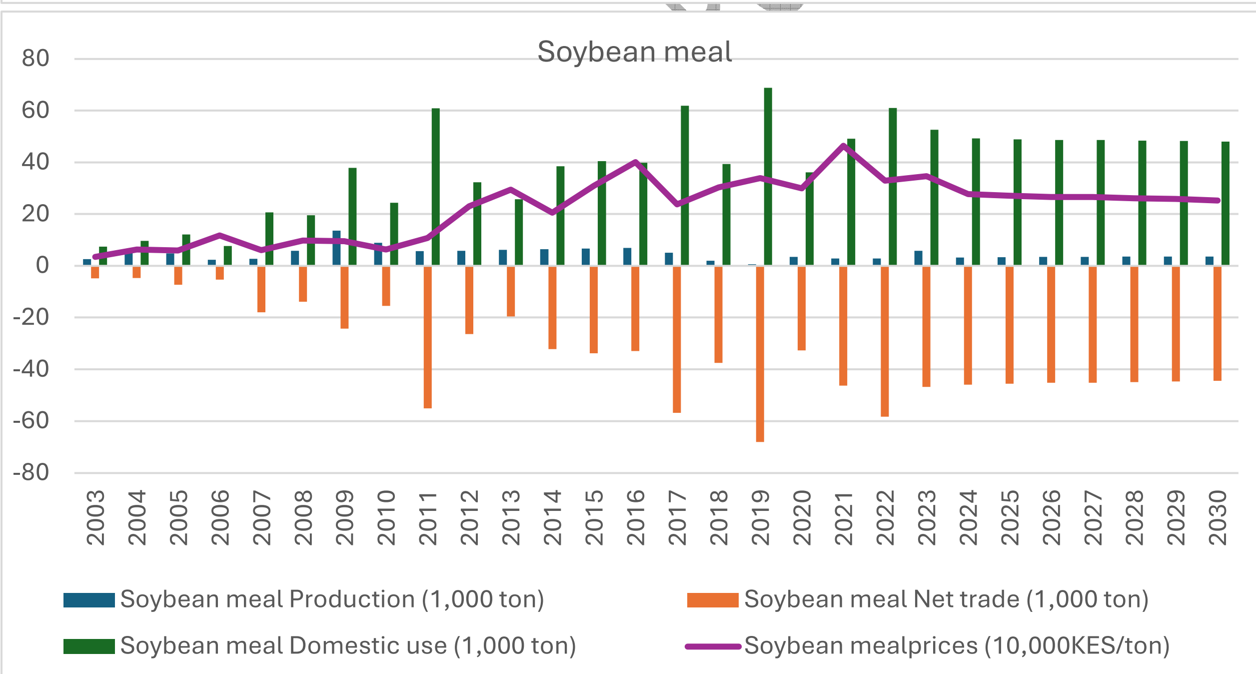


Figure 19: Production, consumption and trade for soybeans in Kenya

Source: PPVC Kenya Soybean PE model

The development of livestock value chains has a direct effect on the soybeans value chain. As shown in Figure 20 Much of the soybean is consumed as meal, primarily for the livestock feed industry, although part of the meal imports are used for other purposes.

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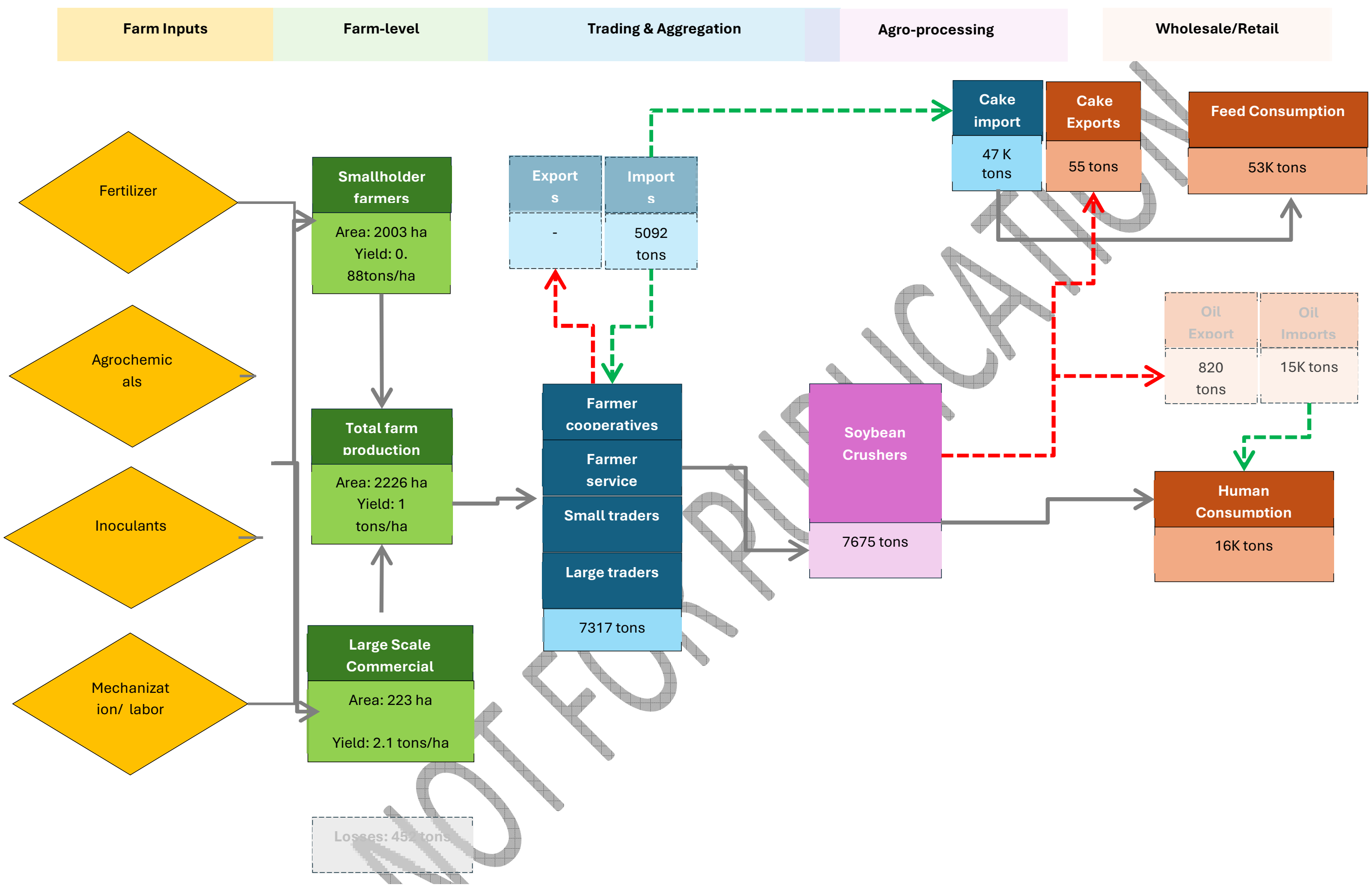

Figure 20: Soybean value chain map

Proposal for GM soybean imports

Feed sector reform is imperative to unlock the fish industry's full potential. The short-term opportunity is to allow the importation of GM raw materials for livestock feed such as GM yellow maize and GM soybeans. In the long term, the government can enhance local production of both maize and soybeans. Reduction of raw materials for feeds will lead to a reduction in the costs of feeds, improve gross margins for farmers and increase supply potentially leading to a reduction in consumer prices.

The proposal to import a quota of the imports as GM soybean specifically for livestock feed manufacture. Soybean are mainly used for fish and poultry feeds. As per the industry's numbers, the estimated demand for soybeans is about 50,000 tons annually. The proposal would be then to cap the quota of soybean imports at 50,000 tons.

Scenario 1: importation of GM raw materials for livestock feed with duty waivers

The simulated effects of importation of GM raw materials, i.e., yellow maize and soybean meal is an increase in farmers gross margins arising from cheaper livestock feeds. Aquaculture and poultry value chains benefit greatly from the reduction in livestock feed prices. Producers are expected to be incentivised to increase production, with an additional 40,000 tons of fish and eggs being produced over the next five years.

Consumers will benefit from improved production with prices of fish and chicken simulated to decrease by 11% and 6%, respectively.

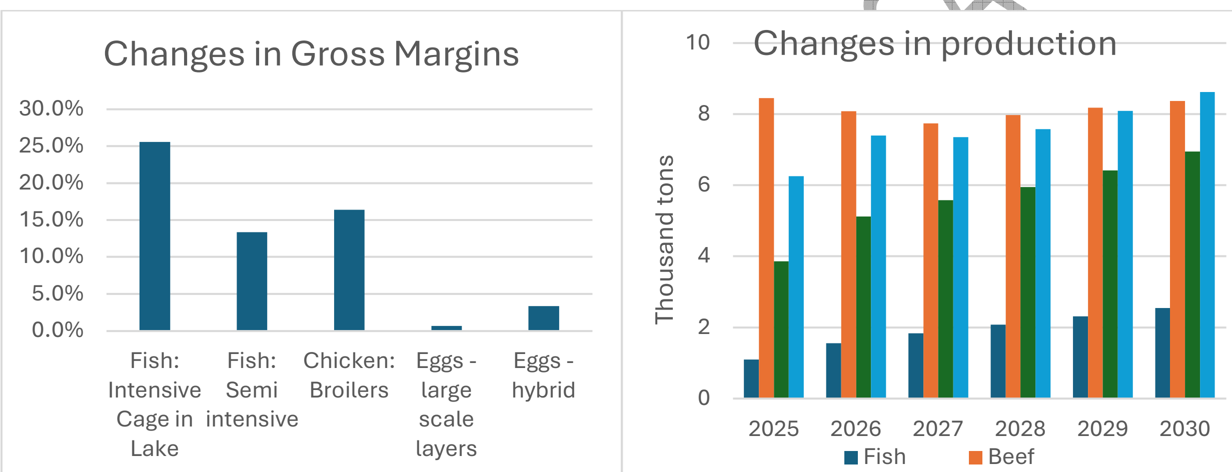

Figure 21: Simulated effects on gross margins and production

Source: PE Model

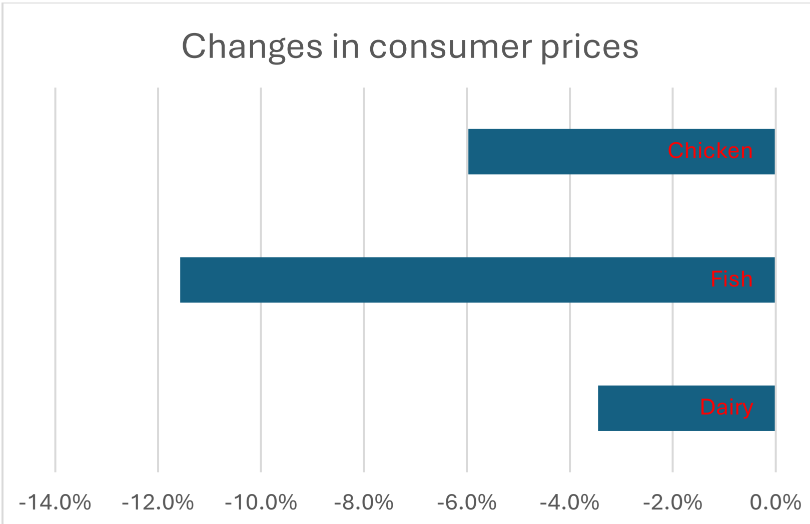

Figure 22: Simulated effects on consumer prices

Source: PE Model

Scenario 2: importation of GM raw materials for livestock feed with duty waivers

Kenya is not competitive in soybean production. Production costs per kilogram (US$ 0.92/kg) are way higher than neighbouring countries, i.e., US$ 0.61/kg for Uganda, US$ 0.58/kg for Tanzania and US$ 0.2 for Zambia. The Kenyan government intends to increase soybean production fivefold, from 2,000 ha to 10,000 ha, to support local edible oil production and increase raw material for livestock feed production. Besides an increase in area, the government plans to provide improved seed and fertiliser to farmers targeted to produce soybeans.

The simulated effect of this intervention indicates that yield could increase from the current 0.8 tons/ha to 1.8 tons/ha. However, given the low base, production is likely to increase from 2,000 tons to 17,000 tons. The increase in production is not big enough to stimulate the processing. The three main crushers have a combined installed capacity for soybean processing of 45,000 tons per annum. This capacity is not being utilized due to lack of raw materials. Furthermore, over the last five years, only 15% of the production has been crushed. As such, soybean meal imports are not likely to significantly change in the outlook.

The combined effect of duty waivers of GM raw materials and an increase in local production of soybeans is an additional 3.77 million in Agri-Food Systems GDP and 3.74 million in overall GDP.

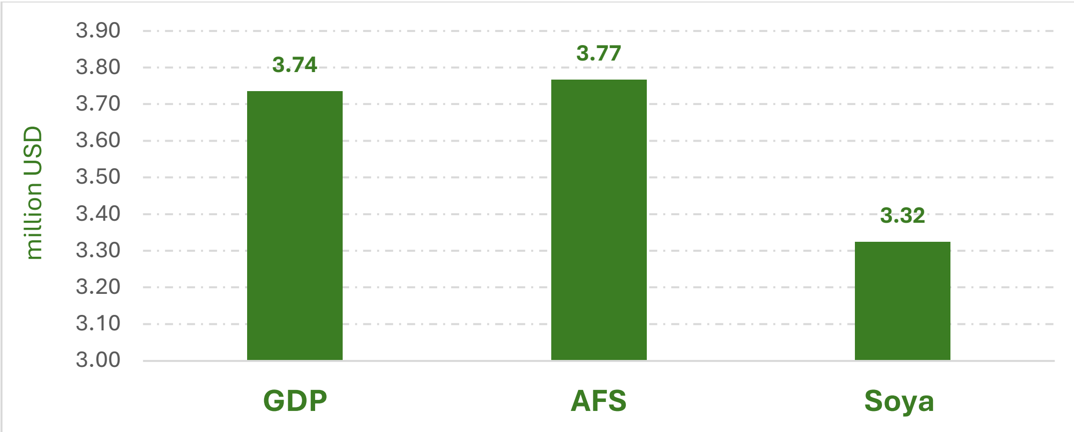

Figure 23: Simulated changes in GDP from proposed interventions

Source: CGE model

Implementing interventions to increase local production and duty waivers on GM raw materials has the largest effect on reducing poverty in both urban and rural sectors.

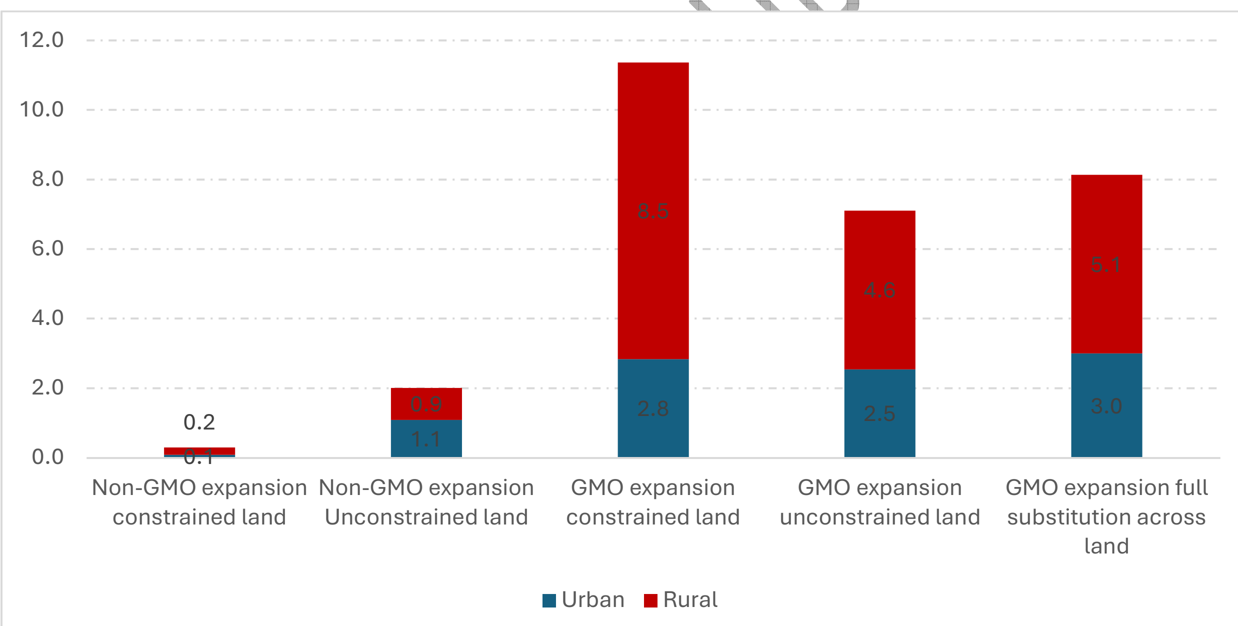

Figure 24 : Simulated changes in poverty headcount from proposed interventions

Source: CGE model