

## Critical Aspects of Aquafeed Value Chain in the Kenyan Aquaculture Sector- A Review

Jonathan M. Munguti<sup>1</sup>, James G. Kirimi<sup>2</sup>, Kevin O. Obiero<sup>3</sup>, Erick O. Ogello<sup>4</sup>, Josiah A. Sabwa<sup>5</sup>, Domitila N. Kyule<sup>1</sup>, David M. Liti<sup>6</sup> & Levi M. Musalia<sup>7</sup>

<sup>1</sup> Kenya Marine & Fisheries Research Institute, National Aquaculture Research Development & Training Center (NARDTC), P.O. Box 451-10230, Sagana, Kenya

<sup>2</sup> Department of Animal Sciences, Chuka University, P.O. Box 109-60400, Chuka, Kenya

<sup>3</sup> Kenya Marine & Fisheries Research Institute, Sangoro Aquaculture Research Station, P.O. Box 136-40111, Pap-Onditi, Kenya

<sup>4</sup> Department of Fisheries and Natural Resources, Maseno University, P.O. Box Private Bag, Maseno, Kenya

<sup>5</sup> University of Eldoret, Department Fisheries and Aquatic Sciences, P.O Box 1120-30100, Eldoret, Kenya

<sup>6</sup> University of Eldoret, Department Biological Sciences, P.O Box 1120-30100, Eldoret, Kenya

<sup>7</sup> Department of Dryland Farming and Natural Resources, Tharaka University College, P.O. Box 193-60215, Marimanti, Kenya

Correspondence: Jonathan M. Munguti, Kenya Marine & Fisheries Research Institute, National Aquaculture Research Development & Training Center (NARDTC), P.O. Box 451-10230, Sagana, Kenya. E-mail: [jmunguti2000@gmail.com](mailto:jmunguti2000@gmail.com)

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### Abstract

This article reviews critical aspects of the aquafeed value chain in the Kenyan aquaculture sector. Aquaculture production in Kenya has grown steadily in recent years, to more than 18,000 tons in 2019. Due to the growing demand for fish and fish products, there has been a gradual shift from extensive to semi-intensive to moderately intensive aquaculture systems, leading to an increased demand for high quality commercial fish feeds. The current annual demand for fish feed in Kenya is estimated at 34,000 tons. It is the lack of sufficient and high-quality local fish feed production that has created a market for fish feed importers, which is currently estimated at 7,000 tons annually. However, the imported fish feed is expensive for most fish farmers, leading to low production. Local fish feed production through home-based formulation should be driven by fish farmers to contain the rising cost of feeds. Most cottage feed manufacturers produce mash, crumbles or sinking pellets because they lack extruder for making floating pellets, hence the need for quality control in the aqua-feed sector. Fish feed producers are weakly covered by financial services providers, hence the inability to compete effectively with other value chains. The paper outlines five key actors in the aqua-feed value chain from production to marketing. These include; raw material (ingredients) suppliers, feed manufacturers (feed formulators), distributors/wholesalers, retailers, and customers who are fish farmers. We recommend intensification of local aqua-feed production using locally available materials to reduce the importation. This will ensure the long term economic and ecological sustainability of the aquaculture sector. There is a need for favourable policies to lower importation rates for raw materials as a way of boosting the availability of additional feed resources and inputs.

**Keywords:** actors, aqua-feed, value chain, Kenya

### 1. Introduction

Successful aquaculture depends on the sufficient production and supply of quality feeds. Aquafeeds can be classified as direct and indirect (Hasan et al., 2007). The direct aquafeeds include commercially manufactured feeds, on-farm prepared feeds and lower market value fish (discards), while indirect feeds are generated by using fertilizers or manure within the culture systems (Hasan et al., 2007; Tacon & Metian, 2015). The indirectly generated feeds including live feeds are rich in natural nutrients and are easily ingestible and digestible by

cultured fish. The live feeds are more crucial for larval fishes that are characterized by smallmouth gape and rudimentary digestive track (Ogello et al., 2020).

Currently, fish feed production is recognized as one of the fastest-growing agricultural sectors in the world (Kong et al., 2020). According to Kumar et al. (2018), the advancement in aquaculture-based technologies, especially in fish feed production and management practices have contributed immensely to the increased production efficiencies for many farmed aquatic organisms. Despite notable variations in production capacities among different countries, aquaculture has collectively realized the highest average growth rate globally (FAO, 2019). In comparison to other forms of food fish production systems, nearly 95% of global aquaculture production occurs in developing nations at an annual growth rate of 6.13% (FAO, 2019). The Asian continent produces 102.9 million tonnes (91%) of the global aquaculture production, whereas the African continent produces close to 2.2 million tonnes, with aquaculture growing at an annual average rate of 9.81% since 2000 (FAO, 2019; Tacon, 2020).

Nearly most of the ingredients used in making feeds in aquaculture are imported (Tacon & Metian, 2015; Tacon, 2020). Initially, many countries relied on indirect natural productivity in their ponds by fertilization, but presently, nearly 70% of the existing aquaculture systems rely on direct aqua-feeds diets (Tacon, 2020). To attain high fish production in aquaculture, quality feed production is a prerequisite. Fish feed quality is a factor of the presence and balance of essential amino acids, which in turn determine protein utilization (Kirimi et al., 2020; Munguti et al., 2021). Production of quality aquafeeds has been made possible due to the technological advances in feed processing equipment, feeds management practices contributing to aquaculture intensification (Kumar & Engle, 2016). In essence, quality feeds improve feed conversion efficiencies and lead to high fish yields to levels comparable with the capture fisheries (FAO, 2018; Kok et al., 2020).

In the past decade, aquaculture has been recognized as one of the flagship projects in Kenya capable of stirring the country's economy (Nyonje et al., 2018; Githukia et al., 2020). This has contributed to the increase in aquaculture production in Kenya, which currently stands at about 18,000 tons annually (Figure 1) (KNBS, 2020). Moreover, the rapid increase in population, incomes and constant campaigns on the health benefits associated with fish consumption have contributed to the current increase in the demand for fish (Obiero et al., 2019). The huge demand for fish can be met if aquaculture intensification strategies are initiated and undertaken sustainably (Munguti et al., 2017).

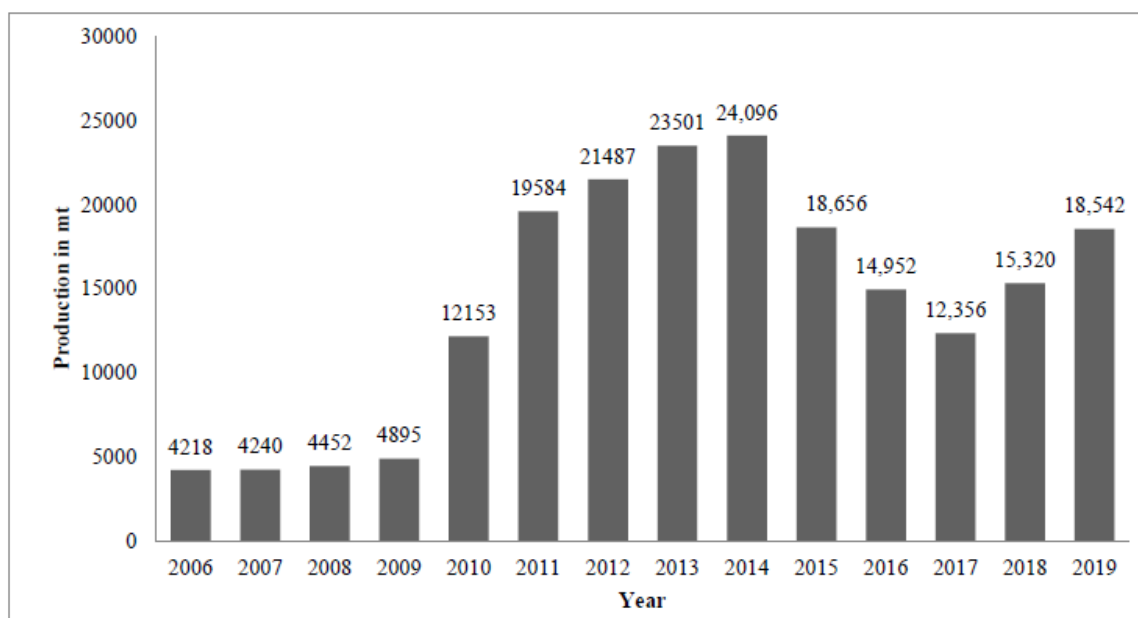


Figure 1. Trends in aquaculture production in Kenya 2006–2019 (KNBS, 2020)

The growing demand for fish and fish products in Kenya has contributed to a gradual shift from extensive to semi-intensive and moderately intensive aquaculture production systems, leading to an increased demand for quality commercial fish feeds (FAO, 2018). However, the cost of quality feeds is very high for most fish farmers,

hence the need for cost-effective but quality feeds that provides the nutritional specifications for each species (Kok et al., 2020). Quality fish feeds and fingerlings are currently the major challenges facing Kenyan fish farmers where the former alone accounts for over 50% of the total production cost (Liti et al., 2005; Munguti et al., 2014b). These challenges result in the overall production of inferior products hence affecting these challenges result in the overall production of inferior products that eventually affect the aquaculture industry.

## 2. The Kenyan Aquaculture Value Chain

Value chain analysis involves the evaluation of the actors and factors that impact the performance of a firm, and relationships among participants to recognize and overcome the major constraints to the expanded proficiency, productivity and competitiveness (Fries, 2007). This performance relies upon the actors, how they identify with one another, how data streams and who controls the value chain (Sturgeon, 2001). In fisheries and aquaculture value chain analysis deals with how the sector receives raw materials as input, add value to them through various processes and sell the finished products to end-users (De Silva, 2011). Aquaculture value chain studies regularly incorporate concerns with value chain structure, most ordinarily conveyed through mapping exercises as well as the conduct of value chain actors (Asiedu et al., 2016; Pomeroy et al., 2017). Coordination in a value chain is the estimates that players make in a market system to act in a correlative manner towards a shared objective and spotlights on the types of relationships between actors (Poulton et al., 2004; Kaminski et al., 2017). Aquaculture is an essential area of the economy that has a high potential to give nutritious food and add to the national economy. Through the value chain linkages, aquaculture adds to socio-economic development, improvement of livelihoods and reduction of poverty (Wangila et al., 2007; Ogello & Munguti 2016). The aquaculture value chain also furnishes policymakers and stakeholders with a methodical apparatus that permits them to comprehend the related processes in the industry and help with advising policy dialogue and investment operations (Asiedu et al., 2015).

Nonetheless, given the nature of aquaculture systems in Kenya, limited investments have been made by actors in the value chain specifically into the quality of inputs and services needed for improvement. In the aqua-feed sector, a steady supply of good quality feed in adequate quantity is often compromised by several factors; key among them is the production of low quality feeds by corrupt fish feed makers (Kirimi et al., 2016; Nalwanga et al., 2009). Likewise, the importation of raw materials increases the cost of feed production, pushing the cost of feeds past the reach of many small-scale farmers. Due to the high cost of quality feeds, most farmers who practise subsistence aquaculture regularly utilize inferior quality home-made feeds that limit the production potential of the culture systems. The cage culture on the other hand in Lake Victoria has presented an intriguing measurement with regards to fish feed interest in Kenya. Most cage operators combine commercial feeds with locally formulated diets or simply use raw feed materials such as *Caradina niloticus* as direct feeds to minimize production cost. However, the culture period is constantly broadened (sometimes to 9 – a year) as the fish take longer to reach the market size.

## 3. Actors in the Aqua-Feed Value Chain in Kenya

There are five key actors in the aqua-feed value chain from production to marketing. These actors include 1) raw material (ingredients) suppliers, 2) feed manufacturers (feed formulators), 3) distributors/wholesalers, 4) retailers, and 5) customers who are the fish farmers. As per Porter (1998), for any value chain to be attainable, actors need to work together without a single business entity traversing the whole chain operation. Hence all actors work together closely from the provision of raw materials to the final consumption of the finished product.

### 3.1 Raw Materials/Ingredients Suppliers

Suppliers of fish ingredients are significant actors in the aqua-feed value chain. They produce and sell milling by-products (cereal by-products) such as maize bran, wheat germ, middlings, rice bran, rice polishings, wheat bran, hominy feed (maize bran with maize germ) and oilseed meals e.g soybean meal, canola meal, sunflower meal which are the raw material in aqua-feed manufacturing. They additionally avail raw materials from inside and outside the nation to feed manufacturers. However, the expense of the raw materials from local millers is higher as compared to those imported from millers within the East African region and beyond. Thus, it is a typical practice for small-scale feed processors to import ingredients from other countries. There is a need to address the many constraints in aqua-feed ingredients acquisition and hence give solutions that guarantee feed safety and quality and in turn, guarantees public health safety and higher fish production. Many marketing agents adulterate animal feed raw materials before selling. Secondly, as these ingredients move down the supply chain their crude protein levels reduce due to poor storage. Ingredients from landing sites and oil mills have better nutritional quality than ingredients from stores and shops (Nalwanga et al., 2009; Kirimi et al., 2016). In the case of soybean meal and bran, sawdust is usually added others add coffee husks in rice bran. In some instances, the

suppliers add even sand to fishmeal a phenomenon that is normally reflected by low crude protein, high crude fibre and increased ash in these ingredients (Nalwanga et al., 2009). The acquisition of these adulterated feed ingredients leads to the formulation of low-quality feeds which eventually affects negatively the growth performance and yields of the cultured fish (Kirimu et al., 2016).

### 3.2 Feed Producers/Manufacturers

Fish feed producers convert raw aqua-feed materials into finished feed products for the specific fish species. There are several commercial fish feed manufacturers in Kenya (Table 1) and a negligible number of farm-made cottage feed producers. The large milling companies are mainly found in towns and have established distribution depots in most urban centers or use leading agro vet stockists and aqua-shops as main distribution outlets. Commercial feed manufacturers typically produce animal feeds for aquatic (2%) and terrestrial animals (34% livestock and 64% poultry) (Figure 3). In Kenya, few companies manufacture aquafeed for all life stages of fish. The feed is manufactured as per the nutrient requirement of fish species. However, the proximate composition of the feed changes according to the size of the fish, with protein, lipid and gross energy reduce with fish size (NRC, 1993). Table 2 shows a list of fish feed manufacturers in Kenya.

Table 1. List of Aqua-feed Manufacturers in Kenya

Fish Feed Manufacturer	Location	Distribution Location	Feed Production Level (MT/Month)	Production Capacity (MT/Month)	Type of Feed	Fish Farmers Served
Jewlet (Feed) Enterprises Ltd	Kendu Bay	Nationally	40	500	Floating and sinking pellets	1,000
Tigoi Fish Feed Company	Kakamega	Vihiga County	1	*	Sinking pellets	200
Matayos Aquafeed SHG	Busia	Busia County	2	*	Sinking pellets	350
Nyawara Animal Feed Plant	Gem, Siaya	Nationally	10	*	Sinking pellets	>50
Deje Farm Products	Sega, Siaya	Siaya and Busia	1	*	Sinking pellets	>100
Awino Fish Feed Limited	Siaya	Siaya	1	*	Sinking pellets	15
Sare Millers	Kisumu	Vihiga County	15	*	Floating and sinking pellets	70
Kenya Marine and Fisheries Research Institute	Sangoro	Nationally	4	48	Floating and Sinking pellets	200
Nyanjiga Farm	Siaya	Nationally	10	*	Pelletizer, Mixer, Miller	200
Mabro Fish Feed Enterprise	Bondo Siaya	Bondo, Siaya	6	*	Hammer, Mixer, pelletizer	70
Aqualife Solutions	Machakos	Nationally	20	500	Floating pellets	50
Sigma Feeds Limited	Rongai	Nationally	72	10,000	Floating pellets	>
Javarih Holdings	Nyamonye, Siaya	Nyanza Region	Nil	*	Sinking pellets,	20
Unga fish feeds- Nairobi	Industrial Area Nairobi	Nationally	300	5,000	Floating pellets	>200
Lenalia Feeds – Limuru	Limuru Kiambu	Nationally	40	1000	Floating and sinking pellets	>100
Bidii Fish Feeds Luanda(not producing)	Emuhaya, Vihiga	Western/Nyanza -Kenya	5	100	Floating and sinking pellets	>70
The total tonnage of local capacity production				17,148		

NB. \*means data not available

### 3.3 Feed Distributors/ Feed Wholesalers

Feed distributors are intermediaries between feeds manufacturers and farmers. They coordinate themselves as wholesalers, who sell to retailers, other merchants and commercial users, but do not sell in significant amounts to the final consumers (Kotler, 1997). Some feed producers (like Unga feed limited and Sigma feeds) have distribution outlets mainly major Agrovets stockists and aqua-shops located in major towns where farmers can easily access the feeds directly. These stockists eventually sell to smaller agro-vets at a wholesale price while selling to farmers at a retail price. Other feed producers deliver the feeds directly to their clients at factory price.

### 3.4 Retailers

They retail fish feed and feed ingredients as demanded by the farmers or small-scale feed producers. Some also offer advisory services to farmers. Unlike wholesalers, they sell different types of feed ingredients and feeds, either unpacked or repacked in smaller quantities. Whereas the stockists are well distributed in local areas, the bulk of the stock value is found in the urban centres (Musalia et al., 2007).

### 3.5 End-users/ Consumers

Both grow-out fish farmers and hatchery producers are the main actors in the aquaculture industry. The majority buy branded feeds from agroveterinarian stockists/ aqua-shops. Other farmers utilize feeds acquired from the feed mills or traders. Some of the problems stockists face in accessing their stocks to farmers include long-distance travelled by farmers, farmers are not aware of the feeds, high prices among many others (Musalia et al., 2007). High quality feeds are usually very expensive and remain unaffordable to many farmers. The high cost can be attributed to high taxes imposed on the entire food production sector. This makes farmers' look for cheaper but low-quality alternatives hence affecting their production efficiency negatively (Chadd et al., 2002). Most farmers are increasingly formulating their feeds at the farm level without considering the quality of the ingredients so long as they are assured of their availability.

## 4. Sources of Aqua-Feed Raw Materials

### 4.1 Locally Produced Raw Materials for Fish Feeds

Production of high-quality feeds requires the availability of ingredients of high quality. Currently, the major animal protein source for aquafeeds production in Kenya is the *Rastrineobola argentea*, locally known as 'Omena', and freshwater shrimp, *Caridina nilotica*, locally known as 'Ochonga'. However, the availability of these resources depends on other factors such as weather seasonality, government-imposed fishing ban among others (Aloo, 2006). Irregular production of the protein sources is a major bottleneck for the sustainable production of aquafeeds. The bulk of ingredients utilized in feed formulation are by-products from cereals and oilseed industries whose availability depends on weather conditions and climate change. This meddles with the supply of raw materials needed for both farm-made and commercial based fish feed manufacturers, consequently directly impacting the final cost of the aqua-feed products (Munguti et al., 2014b).

The supply of ingredients used in the aqua-feed formulation faces competition from other livestock production systems like poultry and dairy production. Besides, single-ingredient feeds lack certain macro- and micronutrients, have anti-nutritional factors and have poor palatability, which prompts low fish growth (Munguti et al., 2014b). The majority of the animal feed manufacturers are livestock feed manufacturers but only a few deals with fish feed hence a huge setback to fish farmers (Nalwanga et al., 2009; Gitonga, 2014).

### 4.2 Imported Raw Materials

The animal feed industry in Kenya generally depends on imported feed ingredients for example maize, wheat and rice by-products, soybean and its derivatives, sunflower, cotton and nut cakes, fishmeal, and micro-ingredients typically utilized as additives (examples include chemical preservatives, vitamins, antibiotics, minerals, fermentation products among many others) acquired from the East African Community (EAC), regional market and other international markets. Nonetheless, imported fish feeds are popular in Kenya despite the high cost due to the perceived quality of feed ingredients (Nalwanga et al., 2009). The high cost is a consequence of increased demand for these ingredients, competition from the animal feed industry, human food needs and other industrial requirements such as the production of bio-fuel. Slight changes in trade policies in the source countries have conceivably influenced the accessibility and cost of animal feed in Kenya. Importation of raw materials increases the price of feed, making it costly especially for small-scale farmers (Munguti et al., 2021).

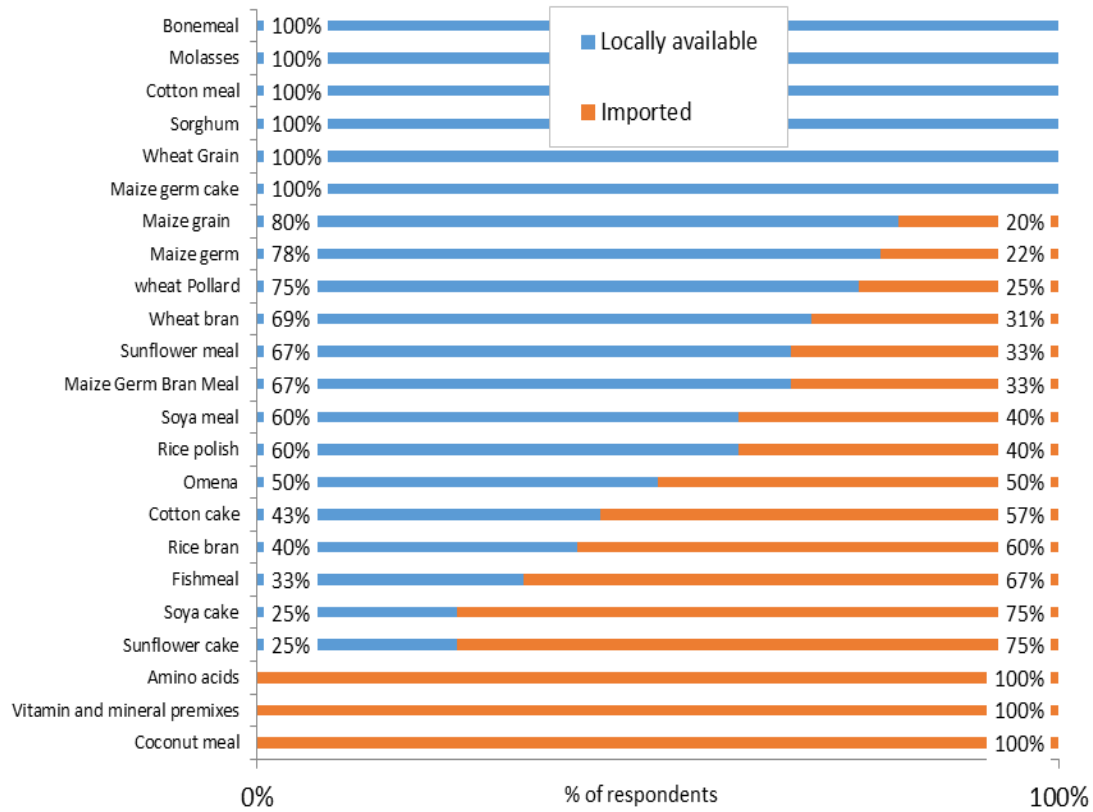


Figure 2. Quantities of locally available and imported fish feed ingredients in Kenya (KMT, 2017)

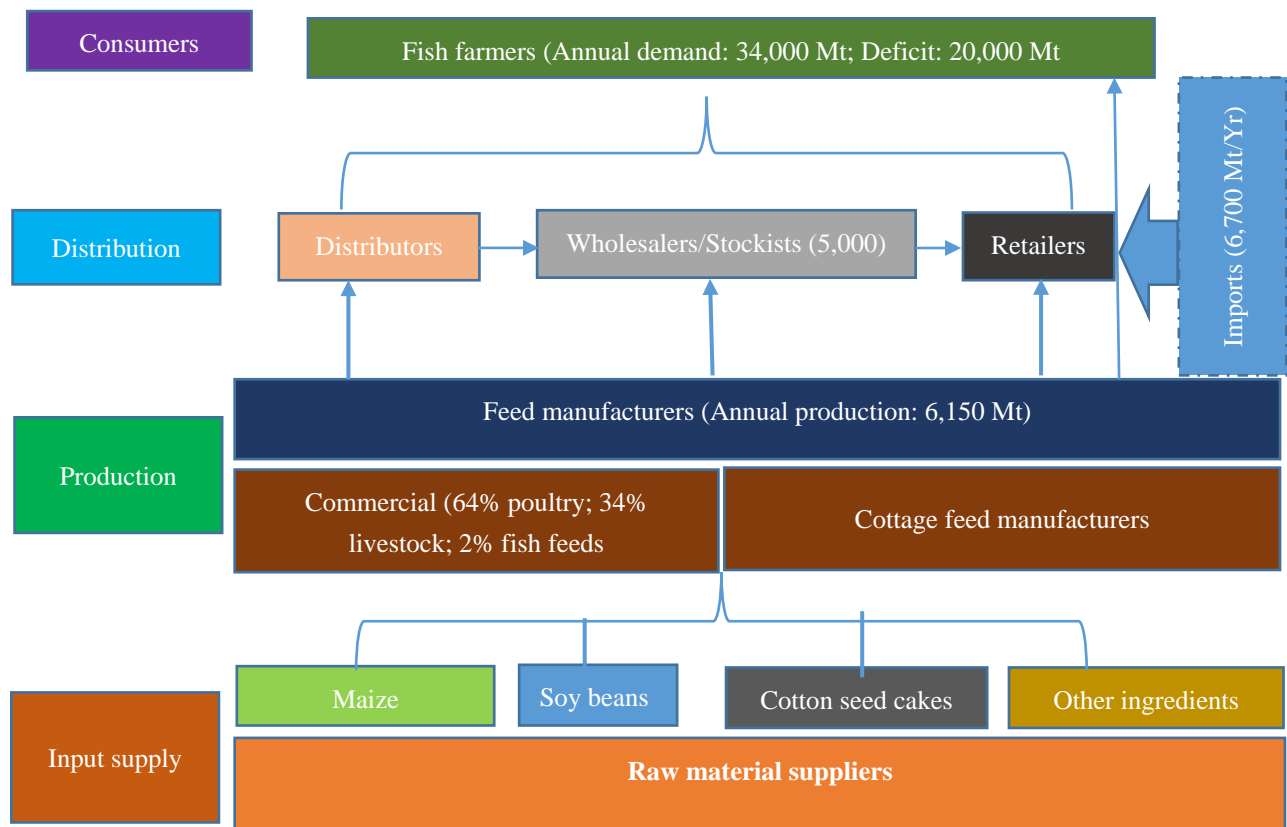


Figure 3. Aquafeed value chain in Kenya

Table 2. List of Fish Feed Importers and Imported Quantities in Kenya

	<b>Fish Feed Manufacturer</b>	<b>Local Dealer/ Representative</b>	<b>Distribution Location</b>	<b>Feed Imported Mt/ pa</b>	<b>Feed type</b>
1	Aller Aquafeeds–Denmark	Cage farms Mwea Aqua Fish Farm Kirinyaga Sare Millers Limited, Kisumu	Siaya, Usenge	250	Extruded feeds
2	Rannan Fish feeds Israel	Samaki Express Limited, Nairobi	Nationally	156	Extruded feeds
3	Novatech fish feeds- zambia	Victory farms	Homabay	400	
3	Skreting fish feeds – the Netherlands	(I) Victory farms	Homa Bay	4500	Extruded feeds
		(II) Unga fish - (catfish)	Nationally	27	Extruded feeds
		(III) Starter tilapia	Nationally	130	
		(IV) Starter catfish	Nationally	100	
		(V) Kamuthanga– Machakos	Machakos	156	Extruded feeds
		(VI) Fresh catch – Athi River	Athi River	102	
4	LFL Riche Terre – Mauritius	(I) Africa blue	Bondo	100	Extruded feeds
		(II) Pindu Fish farm	Kiambu	26	
5	Laguna brazil	Jewlet enterprises	Homabay	600	Extruded feeds
6	Prime feeds - Israel	Africa blue	Bondo	100	Extruded feeds
	Biomar – France	(I) Starter diet–Makindi fish farm Thika	Thika		
7	Novatech fish feeds- Zambia	Victory Farms Limited	Nairobi	250	Extruded feeds
8	Skretting – Egypt	Fresh Catch Limited	Nairobi	122	Extruded feeds
9	Aller Aqua – Egypt	Fresh Catch Limited	Nairobi	25	Extruded feeds
	Total imported tonnage			7,044	

## 5. Fish Feed Millers

Fish feeds in Kenya are majorly produced by the private sector; however, both public sector/ state corporations and parastatals are also in the sector.

### 5.1 Government Millers

The bulk of aqua-feed in Kenya is produced by the private sector. However, the development of quality diet formulations for freshwater fish has recently started with the support of an extrusion feed factory at the Kenya Marine and Fisheries Research Institute (KMFRRI), Sangoro station. The aim is to support the expanding aquaculture sector to fulfil the increasing demand for affordable, safe, and high-quality fish products. In any case, the government ought to guarantee that Aquaculture feed producers centre around the increased utilization of locally available feed resources and reduce the use of imported feed resources and other inputs. This if done ensures a long-term economic and ecological sustainability of the sector. The government can also come up with the right policies that would lower importation rates as a way of boosting the availability of additional feed resources and inputs.

### 5.2 Private Millers

There are few commercial fish feed producers in Kenya. The major feed producers are Unga and Sigma companies. Due to the monopoly enjoyed by the two companies, there is the development of unregulated production of aqua-feeds, including home-made feed that is likewise sold to other farmers.

## 6. On-Farm Feed Production

Farm-made range from basic feed mixtures composed of one or more feed ingredients, moist or cooked feed ingredient mixtures that form semi-moist feed ball or pellets and nutritionally complete formulated diet produced as dry pellets (Hasan et al., 2007; Hasan & New, 2013). The development of locally produced feeds is due to the desire of farmers to contain the increasing cost of feeds (Gitonga, 2014; Munguti et al., 2021). In Kenya, most fish farmers who make their feeds produce them in mash form, crumbles or sinking pellets because they lack extruder for making floating pellets (Nyandat, 2007; Munguti et al., 2014b). Some farmers use improvised pelletizing machines or meat mincing machines and local feed grinders when making their feeds. In most cases, issues relating to the quality of these feeds end up compromising water quality, fish health and growth. Farmers often produce these feeds in low quantities that barely meet their farm-level needs. The quality of these feeds is also compromised especially due to the lack of drying facilities, awareness and knowledge in feed formulation for the different growth stages of fish among many others.

## 7. Services in the Aquaculture Feed Value Chain

### 7.1 Financial Services

The government of Kenya empowers aquaculture advancement by offering credit facilities through the Agriculture Finance Corporation (AFC). However, the level of credit utilized in aquaculture is very low (Quagraine et al., 2010). The majority of fish farmers can access commercial banks and Saccos to deposit cash derived from the sale of their fish. Access to credit facilities remains a challenge to most of the farmers thus making it very difficult to expand their enterprises. The use of credit facilities by Kenyan fish farmers is very low (Quagraine et al., 2010). This is an issue that requires extensive consultations with the relevant stakeholders including insurance companies. There is also a need for capacity building. Traditional agricultural businesses entities like dairy and others can easily access credit from lending institutions, unlike aquaculture enterprises. Only a few financial institutions offer loans to fish farmers, perhaps due to perceived high production risks in aquaculture (Ngugi & Manyala, 2004; Quagraine et al., 2009).

### 7.2 Extension, Information Services and Capacity Building

The State Department of fisheries and the blue economy and directorate of fisheries at County levels are responsible for extension support and information services to farmers. Fisheries officers offer extension and information services. They also train and advise farmers during farm visits, on-farm demonstrations, and other training sessions organized at both county and national levels. Non-governmental organizations and feed providers also provide extension services to farmers through field demonstration and seminars/workshops (Musalia et al., 2007). In his study farmers got information in the following order; training and field demonstrations (57%), visits to other farms (22%) and attendance at shows (21%) (Musalia et al., 2007).

### 7.3 Quality Control in the Aqua-Feed Sector

The quality of commercial feed is assessed in terms of its nutritional composition as well as the presence or absence of substances that may be harmful to both human and animal health (Gitonga, 2014). The supply of high-quality fish feed is compromised by several factors. For instance, some deceitful and corrupt fish feed manufacturers produce low-quality feeds and sell them to clueless farmers (Kiriimi et al., 2016). Notwithstanding, the Government of Kenya (GoK) assumes a significant part in supporting the improvement of the aquaculture sector through the development and implementation of policies and regulations in the fish feed sector. Kenya Bureau of Standards (KEBS), which is a government agency, regulates standards, however, many feed operators and ingredient suppliers are not registered with the institution. Registration will make the operators and the suppliers apply for standardization specifications for specific feed products before releasing them into the market hence assuring of quality. Smaller feed processors are unregistered, unregulated and hard to follow, consequently evading the oversight of KEBS.

With feed cost continuing to rise, ensuring the quality, cost-effectiveness, availability, and optimization of their use, should all be considered as important factors to the promotion of continued growth in the sector. There is a need to allow the fish feed actors to follow the laid down regulations that will check and validate their products to ensure quality. Some fish feed producers have employed competent technical personnel who deal directly with feed formulation and quality assurance. The feed formulation and quality assurance specialists entirely work on feed composition, proximate analysis and interpretation of the analysis. A majority of the feed producers rarely engage these experts hence compromising the fish feed quality (Munguti et al., 2014a).

## 8. Conclusion

This paper characterizes the aquafeeds value chain and distinguishes limitations to its supply and use in Kenya. Some of the challenges associated with the animal feed industry include an erratic supply of raw materials, lack of standardization, and low quality of ingredients. The government ought to establish an enabling environment for the different players in the fish feed industry especially the existing and potential investors. This will involve the ease of registering these feed companies and producers, easy access to credit and other support services to all the players in the value chain. Support research, development and policy for local production of raw materials for feed manufacturing. Additionally, collaboration among actors in the aqua-feed value chain is critical to supply quality and adequate quantity feed, improve its competitiveness and profitability. The level at which farmers' utilize credit facilities is still very low. Hence there is a need to educate farmers, government agricultural lending agencies and other commercial agricultural lenders to put resources into this venture.

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