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Fish feeds and feed management practices in the Kenyan aquaculture sector: Challenges and opportunities

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Feeds and feed management practices are key to the development of the aquaculture sector. To achieve high levels of aquaculture production, fish farmers need nutritionally adequate and cost-effective feeds, which are coupled with good feed management practices. Access to high quality and cost-effective feeds is one of the prerequisites to successful fish farming. This paper reviews the current status of the Kenyan fish feed industry and feed management practices. The review includes constraints and opportunities in fish feeds from a farmer's perspective. The review shows that the fish feed industry has been boosted by the development of fish feed standards, which has ensured access to high-quality fish feeds by all farmers. Feed management practices considerably impact on the economic performance in fish production. Thus, adopting appropriate feed management technologies and feeding strategies is instrumental in maximizing aquaculture productivity. Some of the major challenges faced by fish farmers in the feed sector including limited access to finance, lack of appropriate technical innovations, limited knowledge in feed formulation and processing and poor feed handling and storage are discussed. These challenges pose limitation in investment opportunities for a viable and sustainable fish feed processing and manufacturing to meet the rising demand occasioned by increased demand for fish food in Kenya. There is a huge potential to develop public-private partnerships with farmer groups to improve access to training and information dissemination on feeds availability and quality. Training fish farmers on feed formulation using locally available feed ingredients provide an opportunity to reduce feed costs, increase feeding efficiency and improve profitability. This paper reviews the current status of the Kenyan fish feed industry and feed management practices including constraints and opportunities from a farmer's perspective.

Keywords: profitability, Nile Tilapia, Catfish, feed ingredients, Kenya

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Introduction

According to the Food and Agriculture Organization (FAO), production from fisheries and aquaculture is projected to increase by over 60% to feed the world population by 2050 (FAO, 2014). However, reaching this target is a formidable challenge considering that 821 million people, mostly in developing countries are still suffering from hunger and poverty (FAO, 2018; Obiero et al., 2019). While global capture fisheries production has flattened over the past 3 decades, aquaculture has been growing steadily at an average annual rate of 6–7% (FAO, 2018), and now contributes over half of the fish produced for human consumption (Bush and Oosterveer, 2019). In 2014, a milestone was reached when the supply of fish from aquaculture far overtook capture fisheries for the first time (FAO, 2016; Munguti et al., 2017). With the current expansion of aquaculture activities, the demand for fish feed is in turn is expected to increase significantly (Anderson et al., 2017).

In response to increased demand for fish feeds, nations around the world have continuously developed technologies on feed manufacture and feed management practices to increase fish production efficiencies in aquaculture (FAO, 2012). The technological advances in feed processing equipment and feeding management practices have led to an increased contribution to the total aquaculture production. However, these global figures mask some important regional distinctions. Asia for example accounts for nearly 90% of global aquaculture production, with 62% coming from China alone (FAO, 2014). Also recent statistics reveal that annual aquaculture production during 2000–2012 was fastest in Africa (11.4%), Latin America and the Caribbean followed with 10% (FAO, 2015). Although Africa had the fastest growing rate of more than 20% per year between 2007 and 2014, the region currently contributes less than 2% of the global aquaculture production (FAO, 2016; HLPE, 2014; Waite et al., 2014). In 2012, FAO reported that ten of the fastest growing aquaculture centres were in Africa although in East African countries, aquaculture production is still in infancy stage compared to the top producers in the world. Also there are major differences in production levels among the East African countries, for example, in Uganda and Kenya, the aquaculture sector is relatively more developed than in Rwanda and Burundi; while production in Tanzania, is intermediate (Censkowsky and Altena, 2013; de San, 2013).

The aquaculture sector in Kenya dates back to the 1920s and has seen slow growth for decades until recently when the Government of Kenya stepped up the promotion of commercial fish farming nation-wide. Moreover, Kenya's Vision 2030, together with other policy frameworks recognized aquaculture as one of the flagship projects to revamp the country's economy (Manyala and Ngugi, 2009). Consequently, aquaculture production increased rapidly from 1,012 tonnes in 2006 to a peak of 24,096 tonnes in 2014 after the implementation of the Economic Stimulus Programme (ESP) from 2009–2013 (Figure 1). The ripple effect of the program led to increased demand for fish feeds to over 100,000 MT (Musa et al., 2012; Charo-Karisa and Gichuri, 2010). The increased feed demand resulted in the simultaneous importation of feeds and massive production by small-scale feed manufacturers and from farm-made feeds.

It is widely acknowledged that aquaculture has an important and increasing role in enhancing food security and nutrition in Kenya (Obiero et al., 2019). The enabling policy environment has attracted substantial donor and government support for aquaculture development in the country. For instance, there is an eight-year (2018–2025), USD 143.3 million Aquaculture Business Development Programme funded by the International Fund for Agricultural Development (IFAD) and Government of Kenya (GoK). This project is currently supporting smallholder aquaculture fish production to accelerate and consolidate the expansion of aquaculture production and trade. The implementation of this program which is currently on-going will further lead to increased demand for aquafeeds and will require efficient feeding management practices. Furthermore, increased aquaculture production is positively correlated to the progressive use of quality feeds, which meet the nutritional requirements of the cultured fish and as well as best feeding management practices (FAO, 2018; Munguti et al., 2014). In addition, most Kenyan fish farmers have identified fish feed and feeding management practices as some of the most critical challenges facing the aquaculture sector.

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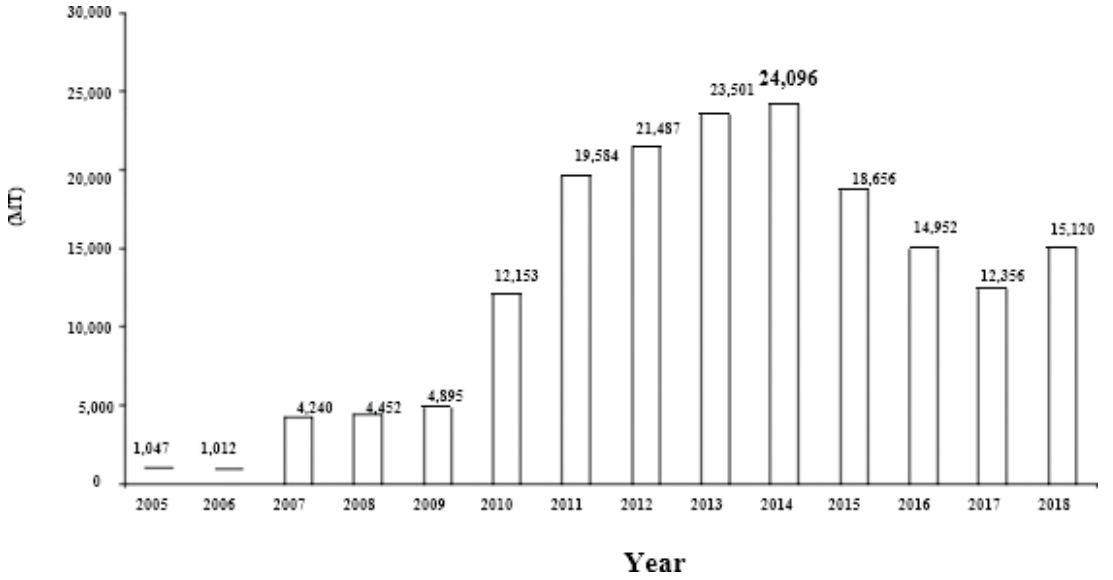

Figure 1. Trends in aquaculture production in Kenya between 2005 – 2018 (FAO, 2018).

The status of the Kenyan fish feed industry

In semi-intensive and intensive aquaculture systems, feeds typically account for between 40–60% of production costs (Shitote et al., 2001; Ali and Jauncey, 2004; Liti et al., 2006). Contribution of 50 percent and above in the total operating cost indicates that fish feed is the most costly item in aquaculture production. The high cost of feeds can considerably reduce the profitability and viability of many aquaculture enterprises. Consequently, there is need for appropriate strategies to be instituted to reduce the high cost of production in aquaculture enterprises. The first step towards making the aquaculture industry more profitable and viable is to ensure that farmers have access to quality and affordable feeds coupled with appropriate feeding management practices. Over 90% of cultured fish in Kenya come from earthen ponds sized between 150 to 800 m^2, which are normally fertilized and fish fed with low-cost agricultural by-products (Ngugi et al., 2007). In this case, most of the nutrition is provided through natural foods, which are cheaper to produce compared to artificial feeds. Another strategy for reducing the cost of feed input was proposed by Diana et al. (1994). The authors demonstrated that a feed reduction of 42% was possible when fish were fed 0.5 satiation feeding with simultaneous addition of complete feeds and fertilizer in ponds. Cage culture has emerged from relative obscurity in the last 5 years and requires feeds that are adequately formulated with high nutritive value as opposed to single ingredients (Aura et al., 2018; Njiru et al., 2018). In this system different approaches are needed to reduce production costs. Among these approaches are feeding the fish slowly to satiation and use of automated and demand feeders. Such feeding strategies ensure that minimal waste of fish feed.

In Kenya, one of the most pressing challenges in aquaculture is the availability of high-quality feeds. The Economic Stimulus Program (ESP) caused a tremendous increase in fish feed demand and as a result, unscrupulous dealers took advantage and compromised the quality of fish feed (Nalwanga et al., 2009; Kirimi et al., 2016). The government responded by formulating fish feed standards for tilapia to streamline the aquaculture sector and ensure high-quality fish feed in the market. The formulation of fish feed standards was a culmination of several negotiations, which involved all aquaculture stakeholders including the Kenya Fisheries Service (KeFS), Kenya Marine and Fisheries Research Institute (KMFRI), the State Department of Fisheries, Aquaculture and the Blue Economy (SDF&BE), commercial fish feed

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Table 1. The Kenyan commercial fish feed standards for intensive tilapia farming fry, fingerlings, growers and brooders (Munguti et al., 2014).

Feed parameters	Fry	Fingerlings	Growers	Brooders
Feeding rate	5% b.w	6 – 8% b.w	3% b.w	3% b.w
Crude protein %	40-45%	35–40%	30–34%	40%
Energy MJ/Kg	≥ 10	≥ 10.5 - 11	≥ 11.5 – 12.5	
Crude fiber CF	≥ 4% (should be less)	≥ 4%	≥ 6%	≥ 6%
Lipids	≥ 8%	≥ 8%	≥ 10%	≥ 10%
Lysine	≥12%	≥ 12%	≥ 12%	≥ 12%
Methionine	≥ 5%	≥ 5%	≥ 5%	≥ 5%
Shelf life (months)	≥ 6	≥ 6	≥ 6	≥ 6
Moisture content	≤ 12%	≤ 12%	≤ 12%	≤ 12%
Enzymes	Needed to improve the FCR			
Pellet size (mm)	Mash	2	2 – 5	2 – 5
Floating pellets (min)	N/A	≥ 2 is this	≥ 2	≥ 2
	%			
Packaging labels	Company address, manufacturing and expiry date.			
Packaging size	5Kg,10 kg, 20 kg, 50kg etc			
Packaging material	Must be airtight (Inclusion levels)			
Acidifiers	Preferred			
Premix (vitamin & mineral)	Mandatory (Inclusion levels)			

Note: b.w means bodyweight.

companies, fish farmers and the Kenya Bureau of Standards (KEBS) (Munguti et al., 2017). The existence of fish feed standards has helped feed manufacturers to improve the quality of their products and assured that fish are safe to eat. The Kenyan fish feed standards are shown in Table 1.

Pond and cage feed management practices in Kenya

In Kenya, most grow out fish are fed twice a day at 3% wet body weight (morning and evening) with feeds containing 26–30% crude protein (CP) while fingerlings are fed at least 3 times a day at 3% body weight with 30–40% CP diets (Munguti et al., 2017). Feeding is done mostly at 1000 and 1600 hours preferably at the same spot, when dissolved oxygen levels have improved from the night's down fall. This practice is based on semi-intensive pond culture where natural food is present. Given the increasing scarcity of water, land and other aquaculture resources limitations in Kenya, farmers have gradually shifted towards more intensification through cage culture, and specifically in Lake Victoria. The explosion of cage culture has exacerbated the already existing problems in availability of high quality feeds in Kenya since availability of natural foods in the cages is minimal (Njiru et al., 2018). The sustainability of the increased aquaculture production must be supported by a corresponding increase in the production of specifically designed feeds for the cultured aquatic animals (Rahman et al., 2013). Development and management of fish feed play a vital role in aquaculture growth and expansion. Fish feed management is also a determinant factor of profitability in any aquaculture venture (Gabriel et al., 2007).

Strategies for optimizing fish feed management

Optimization of feeding strategies requires determination of appropriate feed rations and feeding frequencies, and feeding times that take into consideration the endogenous feeding

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rhythms of the farmed species (Shipton and Hasan, 2013). Farmers using commercially manufactured feeds require technical support to assist them in understanding and interpreting the feeding schedules provided by commercial feed manufacturers. In some cases, feed manufacturers need to work with the farmers to ensure that feeds are used appropriately and properly in order to promote better production outcomes and establish a long term commercial relationships with fish farmers. This co-operation will ensure sustainable outcomes in terms of economical use of feeds.

Farmers using farm-made feeds are less likely to have access to information from commercial feed manufacturers. In the absence of this information, the farmers producing farm-made feeds have found it difficult to determine and provide appropriate feeding schedules to fellow farmers.

Therefore, a clear need arises to train the farm-made feed manufacturers in the feed management practices, including determination of feeding schedules, use of feed tables and maintenance of feedstocks and keeping production records. There is tendency of some farmers to over-feed the fish in the mistaken belief that increased feeding always results in higher growth rates, which is not true. In fact, the idea of restrictive feeding where the fish are left unfed for one day in every ten days to induce compensatory growth, needs some consideration (Duong et al., 2011). This approach has been demonstrated successfully in experiments with the African Catfish (*Clarias gariepinus*) but it is yet to be adopted in commercial fish farming (Hecht, 2013).

Feed formulation challenges

Nutritionally balanced feeds are prerequisite to cost-effective aquaculture production. Provision of species-specific feeds that address the nutritional requirements of the different life stages of fish is still a formidable challenge for some feed manufacturers (Oso et al., 2006). Most of the feeds formulated by local manufacturers are based on international laboratory analyses of high-quality ingredients in the literature and only a few have been formulated based on analyses locally. In addition, the formulations lack supportive scientific research on their efficiencies in fish production (Nalwanga et al., 2009).The situation is exacerbated by feed manufacturers who do not consider the nutritional requirements of their farmed species during feed formulation. Indeed, the use of inappropriate feed formulations is a common problem in the Kenyan fish farming sector. Furthermore, some Kenyan farmers use commercial grow-out formulations that contain a far higher level of dietary protein than that is required while others use commercial feeds designed for a completely different fish species. Although a significant amount of research has been undertaken to establish the nutritional requirements of the local species (Munguti et al., 2014; Liti et al., 2006), much of this information has not yet been disseminated to the farm-made feeds producers or to small-scale feed manufacturers. Some farmers producing farm-made feeds are in most cases unaware of the nutrient requirements of the target species. Notably, information on dietary protein and energy ratios and how these requirements change over the life cycle of the farmed fish is still lacking (White, 2013).

Feed processing challenges

The quality of feed ingredients, formulations, manufacturing processes and texture of feed produced can significantly affect the performance of feed (Hasan and New, 2013). Selection of low cost and high-quality ingredients with proper processing into complete feeds is equally important to the overall profitability of the aquaculture enterprise. Although feed processing is often given little emphasis in fish feed manufacturing, it represents a significant portion of feed costs and can offer an opportunity to influence animal performance beyond nutritional adequacy. It is well recognized that prior processing before feed formulation will directly impact growth and feed conversion efficiency; and this is not apparent to local feed producers who are often unaware that feed processing technology has a significant effect on feed quality.

In Kenya, many of the feed ingredients that are used in farm-made tilapia feeds are poorly milled and fail to conform to the recommended standards. As such the ingredients have poor binding properties, which leads to the loss of feeds and nutrients in the water column, resulting in low ingestion rates and high economic feed conversion ratios (eFCR). Therefore, there is a

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need to encourage farmers to use simple extruders and feed binders to compound the feed ingredients into pellets. Improving milling and the binding characteristics of the pellets reduces the amount of fines, improves pellet texture and pellet stability in water, eFCR, and results in cost savings to farmers (Munguti et al., 2014). Improvement on the farm-made and small-scale feed manufacturing sectors is more likely to bring significant gains to the aquaculture sector in general (Hasan and New, 2013).

Feed transportation, storage and handling challenges

Most Kenyan farmers are generally not aware of the importance of proper handling of fish feeds. Inappropriate application of transportation techniques, handling and storage of fish feeds degrades the quality of the feeds. For example, transporting feeds in open trucks, motorbikes and bicycles expose the products to high moisture content, therefore, enhancing the chances of infection by fungi. Prolonged storage in unfavourable conditions also may lead to infestation by pests, which negatively impact on feed quality and yield low fish production (Awity, 2013). In summary, inappropriate feed storage conditions lead to nutrient losses, feed spoilage, lower fish yields and poor economic returns. It is recommended that feeds be stored in cool well-ventilated stores that are not exposed to the extremes of temperature and humidity changes and be protected from pest infestations. Also feeds should be used on a first in, first-out basis. Better management guidelines focusing on feed storage and handling issues need to be developed and disseminated to the farmers (Bene and Heck, 2005).

Opportunities in the fish feed sector

There are several opportunities in the fish feed sector. The main opportunity is for the investors in manufacture of fish feeds, who include large, medium and small scale. These investors in turn create employment opportunities for both skilled and non-skilled personnel including among others plant operators, feed inspectors, and laboratory technicians for conducting proximate analysis of feed ingredients and finished formulations. Other opportunities exist for suppliers of various products including feed ingredients, vitamins and mineral premixes and the machinery for milling and pelleting. Also other beneficiaries include transporters and distributors of fish feeds. Governments too are beneficiaries of the fish feed industry because of the funds they raise through taxation. Generally the fish feed industry can be considered as a suitable vehicle for poverty reduction, especially in developing countries.

Conclusion and recommendations

Providing farmers with well-balanced feed at cost-effective prices is a prerequisite to profitable and sustainable aquaculture production. Much of the aquafeeds in East Africa and Kenya, in particular, are supplemental farm-made feeds either produced on-farm or by small-scale feed manufacturers, and improvements in the quality and processing of the feeds are key to improved productivity and cost savings. For optimum fish production in Kenya, the feed industry needs improvement to provide quality and affordable feeds to fish farmers. Information on appropriate feed formulation techniques and processing technologies must be disseminated to the farmer and commercial feed processors. Formation of farmer clusters and associations should be encouraged as an effective platform for information dissemination and promotion of farmer to farmer training. Besides, identification and training of innovative farmers to train other farmers, and run farmer field schools have proved successful and need to be strengthened. It is important that the training should focus on improvement on feed formulations, which are targeted at species-and life-stage specific diets. Training is needed to improve the knowledge of ingredients quality, nutrient composition and selection, manufacturing processes, storage, and other feed management practices.

There is need for small-scale feed manufacturers and farmers who produce own feeds to have access to real-time market information to foster adoption and intensity aquaculture production. Improving education and extension services delivery in areas under fish feed production are vital. The local media also is a vital component in providing

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market information to farmers on feeds supplier details, feed ingredient availability, quality and price to help in the development of cost-effective farm-made feeds. Farmers and small-scale feed manufacturers need awareness on the abundance and seasonally of available feed ingredients and how they can be incorporated into feed formulations with adequate binding to avoid nutrient loses. Enactment of policies to reduce the prices of feed, e.g. reduction in tariffs on imported feeds and feed ingredients, will provide a catalyst for enhancing the availability of fish feeds in Kenya. A review of the governance mechanisms and the role that legal, policy and regulatory framework on feed quality issues need to be in place in a bid to control the fish feed sector.

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