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ECONOMIC IMPLICATIONS OF UTILISING LOCALLY PRODUCED FEEDS VERSUS IMPORTED COMMERCIAL FEEDS FOR AQUACULTURE SUSTAINABILITY IN MALAWI

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ABSTRACT

This study aimed to assess the economic implications of utilising locally produced feeds compared to the use of commercial fish feed imports on the sustainability of the Aquaculture Industry in Malawi. The growth performance of shire tilapia (*Oreochromis shiranus*) was assessed, and a cost-benefit analysis of utilising local feed production compared to commercial fish feed imports was conducted. Four diets were evaluated: three from local commercial fish feed producers (T1, T2, and T3) and one imported commercial fish feed (T4). There was no significant difference ($p > 0.05$) for the growth parameters of T3 and T4, summarised as follows: mean weight gains of 16.6 g (T3) and 17.48 g (T4); average daily weight gains of 0.16 g day^{-1} (T3) and 0.18 g day^{-1} (T4); and average specific growth rates of 5.47% day^{-1} (T3) and 5.47% day^{-1} (T3). However, there was a statistical difference ($p < 0.05$) in the feed conversion rate for T3 (2.81 g g^{-1}) and T4 (3.03 g g^{-1}). A proximate analysis of the four feeds was conducted to determine the macronutrient levels in each diet.

The fish feed value chain in Malawi was mapped and assessed to identify key players and the strengths and weaknesses existing in the value chain. Key players were categorised according to their functions as suppliers of raw materials and commercial feed imports, local producers of fish and feed, traders, and final consumers. Key challenges identified include a lack of quality assurance regulations, no clear regulation of players' functions and roles, and the need to subsidise the importation tax of raw materials for local feed production. The results of the cost-benefit analysis indicate that, according to NVP, imported fish feed is presently more profitable; BCR indicates that local feed production has the potential to bring substantial net benefits; and lastly, IRR indicates that local feed production is not profitable. However, the local feed production venture has the potential to be profitable and present social benefits for the country.

Keywords: Fish feed value chain, cost-benefit analysis, aquaculture, Malawi

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1 INTRODUCTION

1.1 Background

Aquaculture was introduced in many African countries around the turn of the 20th century to satisfy colonial and recreational fishing needs (Land O'Lakes, 2016). With depleting natural stocks, aquaculture has quickly become an alternative form of sustainable food production to improve nutrition in rural areas, supplement income generation for inland families, diversify to evade crop failure risks, and develop jobs (SARNISSA, 2021). Consequently, many fish farming stations were established by governments across Africa in the 1950s, resulting in 300,000 active production ponds across Africa (SADC Secretariat, 2016).

Africa's contribution to global aquaculture production remains low, estimated at approximately 2.7% (SADC Secretariat, 2016). Larger-scale investments in Egypt, Nigeria, Uganda, and Ghana have made these countries the biggest producers in Africa, with production increasing twentyfold between 1995 and 2018, from 110,200 to 2,196,000 tons, with a compound annual growth rate of 15.55% (SADC Secretariat, 2016). Approximately 99% of production is from inland freshwater systems and is dominated by the culture of indigenous and prolific species such as tilapia and African catfish, with mariculture contributing 1% to the total production (SADC Secretariat, 2016). As Africa's aquaculture industry strives toward commercialisation, new aquaculture production techniques, such as tanks and cages, are taking precedence over existing ones.

Against this background, countries in the southern region came together to prioritise the development of aquaculture and form the Southern African Development Community (SADC), composed of 15 Member States, of which Malawi is one. Through the SADC, the region has received much policy and donor attention over the past 30 years, but the results have generally been disappointing. Sustainable Aquaculture Research Networks in Sub-Saharan Africa, an analytical evaluation of national aquaculture policies and programs in 10 countries, including Malawi, was conducted to explain why aquaculture development has lagged expectations and to suggest a potential for improvement. The study concluded that to sustain aquaculture output, policy objectives should be tailored to various aquaculture sectors, as each contributes differently and has vastly different development restrictions and support needs (SARNISSA, 2021).

As a member of the SADC, Malawi has regional benefits from such collaboration such as the trade agreement Malawi has with Zambia to gain access to fish feed imported to Malawi. However, this is not sustainable for the aquaculture industry in Malawi and has proven to be expensive for local fish farmers and private investors willing to expand their aquaculture production. Hence, there is a need for targeted policies that will provide an enabling environment for local feed manufacturers to thrive and create a self-reliant industry in Malawi that will help reduce production costs for fish farmers in the country.

The most established commercial fish feed manufacturers in the SADC region are located in Zambia (Mwema et al., 2021). However, the government, through the Department of Fisheries, has permitted private enterprises to produce feed in the nation, whereas feed currently imported from Zambia is subject to a 16% import duty, making it more expensive (Mwema et al., 2021). The high cost of imported fish feed renders aquaculture unsustainable for local fish farmers and private investors in Malawi. Consequently, the supply of fish to the local market remains insufficient to meet domestic demand, leading to reliance on fish imports to compensate for this deficit. Malawi faces an estimated annual supply demand gap of approximately 20,000 t (NASP, 2021).

Aquaculture production in Malawi grew from 4,984 tons in 2015 to 9,230 tons in 2019 (NASP, 2021). Currently, 20% of the 7,000 fish farmers operate as semi-commercial and full-commercial, with a primary focus on cultivating *Oreochromis shiranus* (O.S) species (Landell Mills, 2016). These farmers are willing to purchase fish feed in quantities of 210 metric tons, with a value of approximately 61.8 million Malawi Kwacha (MK) (US$ 86,000) (Landell Mills, 2016).. This trend reflects a clear shift towards commercialisation within the industry, aligning with Malawi's vision for 2063 of becoming an inclusively wealthy, self-reliant, and industrialised upper middle-income country (National Planning Commission, 2020).

The use of commercial feed is estimated at less than 10%, and most users are commercial farms because small-scale farmers cannot afford them (Mwema et al., 2021). Feed constitutes 70% of the total production cost (Jauncey, 2000). Several factors contribute to the high cost of fish feed. For instance, all micro-ingredients in feeds, such as fishmeal, premixes, and vitamins, are imported and resold at a profit by feed manufacturers. This, in turn, keeps the price of commercial feeds relatively high, resulting in low demand among smallholder farmers.

Various government and donor-funded projects have in recent years spearheaded and encouraged local private investments in both the fingerling and feed industries, while also promoting best management practices (NASP, 2021). While supporting the development of locally produced feed holds promise for reducing feed costs, there is a lack of evidence regarding their growth performance, production efficiency, and distribution possibilities (Landell Mills, 2016).

Therefore, this study was conducted to assess the production performance of all commercially available feeds (imported and locally produced) sold in the Malawi market. At the time of the study, four commercial fish feeds were available on the market: Apoche, Teren Agro, NAC, and Novatek fish feeds. The last one is an imported feed from Zambia, whereas the others are locally produced. The feed value chain will be assessed and mapped to identify key players and their roles in the value chain, while also tracing the monetary flow through the chain. This will also help identify the strengths and weaknesses of the value chain. A cost-benefit analysis will be performed to assess whether it is sustainable to continue using imported versus locally produced feed.

The results of this study will help achieve Sustainable Development Goal 14 through the promotion of sustainable aquaculture practices to preserve and lessen pressure on capture fisheries biodiversity. This study aims to provide investment guidance to fish farmers and assist policymakers in making or optimising existing policies. This, in turn, will assist in creating an enabling environment for all stakeholders involved in the fish feed value chain to enhance the sustainability and commercial viability of the aquaculture sector in Malawi. The study outcomes are anticipated to advance the achievement of Sustainable Development Goal 14 by promoting sustainable aquaculture practices that conserve biodiversity and reduce pressure on wild fish stocks. This study also seeks to offer investment guidance to fish farmers and assist policymakers in improving existing policies and shaping new ones. Consequently, all players involved in the fish feed value chain will have increased possibilities to improve the sustainability and economic feasibility of Malawi's aquaculture sector.

2 RESEARCH OBJECTIVES

2.1 Main objective

This study aimed to assess the economic implications and efficiency of continuously using commercially imported feeds versus locally produced feeds on the sustainability of the aquaculture industry in Malawi.

2.1.1 Specific objectives

i. To assess and validate the effect of imported commercial feed compared to locally produced commercial feed on the growth performance of *Oreochromis shiranus*.

ii. To better understand Malawi's aquaculture fish feed value chain through mapping, key stakeholder identification, and analysis of its strengths and weaknesses.
iii. To conduct a cost-benefit evaluation to determine the sustainability of using imported commercial feed compared with locally produced commercial feed.

3 LITERATURE REVIEW

3.1 Overview of aquaculture in Malawi

The Fisheries Sector plays an important role in food and nutrition security (SADC Secretariat, 2016). Malawi's production of 186,732 metric tons constitutes over 70% of the nation's intake of animal protein for dietary purposes and contributes 40% to the total protein supply (Department of Export, 2023). There is still significant potential for expanding aquaculture in Malawi, given that the available land is estimated to be over 11,000 km^2 (Tran et al., 2022).

However, Malawi is still far from meeting its domestic fish demand, as the availability of indigenous fish from capture fisheries remains insufficient, with an estimated supply demand gap of approximately 20,000 tonnes annually (Mwema et al., 2021). Aquaculture presents an opportunity to increase the income and nutrition of rural households while also contributing significantly to the national agricultural diversification drive, as outlined in the Malawi 2063 agenda (Munthali et al., 2022).

Malawi's aquaculture production underwent expansion during the 1950s through the establishment of the government-run demonstration centre, called Domasi Research Centre. This centre was established to enhance the breeding and distribution of high-quality fingerlings, demonstrate different production systems, and develop fish feed production methods (Landell Mills, 2016). The aquaculture sector in Malawi has on record a total of about 17,012 fish farmers as of the 2023 financial year, of which 61.51% are male and 38.49% are female (DoF, 2023). Nationwide, there are currently 11,000 active ponds covering 276.15 hectares (DoF, 2023). Aquaculture production continues to increase, and in 2022, 7,148 metric tons of fish were harvested from ponds and cages compared to 9,324 metric tons in 2021. International NGOs and donor agencies have been implementing aquaculture-related projects; however, these efforts have yielded limited success due to key factors, including the limited availability of good-quality fingerlings and fish feed (Landell Mills, 2016; Munthali et al., 2022).

There has been an influx of commercial feeds into the Malawian market from both local producers and imports from Zambia, with the latter dominating the market. Fish feed is often offered in 25 kg packages, despite consumers' continuous and frequent need for feed in lower quantities, ranging from 1 kg to 5 kg. One of the main challenges faced by farmers is the limited availability of fish feed and its high price. There is a need to improve value chain linkages to ensure that farmed fish reach the desired market weight of 200 g and above in significant volumes and of acceptable freshness to meet the nutritional needs of the country's population (Landell Mills, 2016; Munthali et al., 2022).

3.2 Commercially important aquaculture species in Malawi

Four main species are cultured in Malawi: *Oreochromis karongae* (chambo)*, Oreochromis shiranus* (shiranus tilapia/makumba)*, Coptidon rendalli* (red-breasted tilapia)*,* and *Clarias gariapinus* (African catfish*)*. Of the four species, *C. gariapinus* has shown to be a satisfactory candidate in aquaculture, but tilapias (*C. rendalli, O. karongae*, and *O. shiranus*) have not performed as well. Hence, research on other exotic fish species, common carp, and rainbow trout (Table 1) was carried out as potential aquaculture candidates. However, the Malawi Government restricts the uncontrolled importation of exotic fish species into the country as a sustainability measure to safeguard the evolutionary, ecological, and economic importance of the species diversity of endemic fish fauna in Lake Malawi. As such, these exotic aquaculture species are only cultured in controlled government facilities, such as the Domasi Aquaculture Centre.

Table 1: Aquaculture candidates (indigenous and exotic) and their production in Malawi (2001 – 2019)

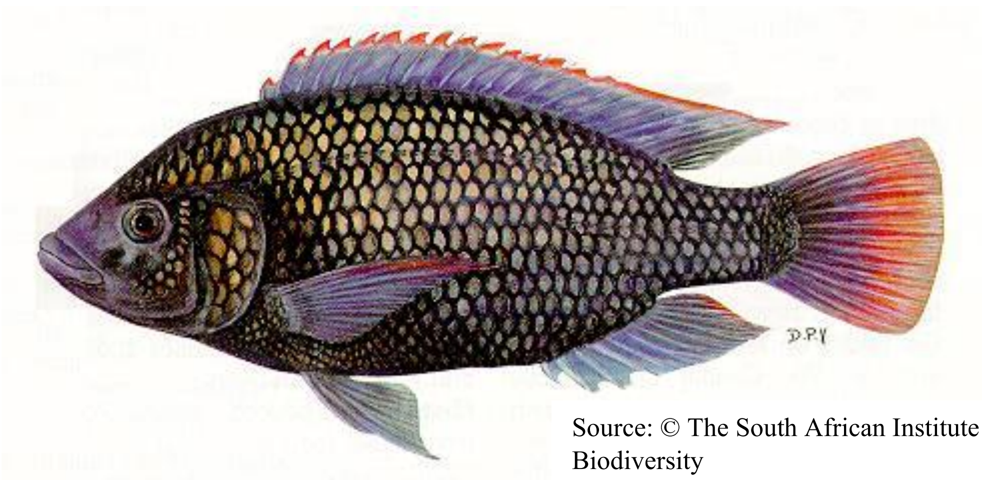
Species	**Year/Production (tonnes)**								
	2001	**2003**	**2005**	**2007**	**2009**	**2011**	**2013**	**2017**	**2019**
Common carp	10	4	7	10	25	76	71	44	11
Mozambique/shiranus tilapia	600	680	83	100	75	1420	2578	8624	6553
Red-breasted tilapia	12	85	61	85	75	862	641	2593	1871
Tilapia nei			623	1260	1350				
African catfish	18	17	21	25	80	175	333	900	782
Rainbow trout	8	15	17	20	15	98	82	56	12
Total	648	901	812	1500	1620	2631	3705	12217	9229

Source: (National Aquaculture Strategic Plan (2021-2031), 2021)

Makumba, the local name for *O. shiranus,* is a deep-bodied species with four, and rarely three or five, anal fin spines. Species from the Lake Malawi catchment area have dark olive bodies with yellow-gold bellies, whereas other populations, such as those from Lakes Chilwa and

Chiuta and the Ruvuma system, have silvery bodies (Froese & Pauly, 2023). It is also characterised by horizontal stripes and vertical bars (Figure 1). Adult males develop large jaws and concave head profiles. They are black with red margins on the dorsal and caudal fins and appear uniformly black when they are removed from the water. These species tolerate temperatures ranging from 23.0-42.0 °C and feed on detritus and phytoplankton (Froese & Pauly, 2023).

Similar to many tilapia species, the protein requirement of this species decreases with age and size, with higher dietary crude protein concentrations required at the fry (30–56%) and juvenile (30–40%) stages, while the grow-out stage requires 28–30% crude protein (Mjoun et al., 2010). *O. shiranus* is the main species of interest because it is a commercially important species in Malawi and is currently under the Genetic Improvement program. It is expected to be the dominant fish species distributed and cultured by farmers in Malawi (Froese & Pauly, 2023).



Source: © The South African Institute for Aquatic Biodiversity

Figure 1: An adult male *Oreochromis shiranus* (Makumba)

3.3 Malawi fish feed industry

Feed production is an essential component of commercial aquaculture development. Currently, Malawi imports approximately $ 5.9 million worth of floating fish feed annually, which is the most common feed problem among fish farmers (NASP, 2021).

According to studies by Landell Mills (2016) and Munthali et al. (2022), feed imports from Zambia sell for $21.01 for every 40-50 kg bag, which makes about $ 21.46 per kg, customs, and shipping fees excluded. As a result, both merchants and fish growers face high feed costs. According to the survey's outcomes, information gathered from extension workers indicates that if the feed was manufactured locally, the price would be lower, varying from MK 16,000-

20,000 per bag ($0.5 per kg) (Landell Mills, 2016; Munthali et al., 2022). (*The currency conversions are according to the current forex rate of the year 2024.)*

Supporting the growth of locally produced feeds at reduced prices is a promising venture; however, evidence is lacking to guarantee the production and distribution of these products. At present, smallholders with access to imported fish feed are doing so through subsidised programs by NGOs; this is evidence that not many would continue with this type of expense when the help is withheld (Landell Mills, 2016).

In the country, a public-private partnership (PPP) model was adopted, allowing individuals or organisations from the private sector capable of operating feed processing facilities, production, and supply to invest in fish feed manufacturing. The Department of Fisheries, to boost aquaculture productivity and enhance access to high-quality inputs such as feed, leads the Sustainable Fisheries, Aquaculture Development, and Watershed Management Project (SFAD), backed by the World Bank (DoF, 2019). Through the SFAD project, farmers were introduced to and trained on the importance of using quality fish feed. This resulted in tremendous growth in farmers' demand for fish feed and opened the door for local investors to find potential in investing in fish feed production. Some of the known local feed producers at the time of this study are Apoche fish feed, Teren Agro, and Domasi Aquaculture Centre (mainly for on-farm use), while the dominant fish feed import is Novertek fish feed from Zambia.

3.4 Fisheries and aquaculture policy in Malawi

The primary objective of the Department of Fisheries is to enhance the sustainable use of fisheries resources and foster the development of aquaculture to strengthen both food security and economic prosperity within the country (DoF, 2021). Its authority is derived from The Fisheries Act of 1949, which was revised in 1965, 1973, and 1997. Currently, all activities related to fisheries and aquaculture are governed by the Fisheries Conservation and Management Act of 1997 (DoF, 2021). However, the Fisheries Acts of 1966 and 1973 overlooked aquaculture, which the Fisheries Conservation and Management Act of 1997, also known as the Fisheries Act, prioritised significantly (DoF 2021). Despite the legislation's focus on aquaculture, it lacks comprehensive regulatory mechanisms to effectively guide sector growth. Therefore, there is a need to establish robust regulatory frameworks to support sustainable development in the aquaculture industry.

4 RESEARCH METHODOLOGY

4.1 Objective 1: To assess the effect of different commercial fish feeds on the growth performance of *O. shiranus.*

A growth performance assessment study was conducted at the Domasi Aquaculture Centre in Domasi, Zomba District, Malawi. Four diets were assessed: three from local commercial fish feed producers (T1, T2, and T3) and one imported commercial fish feed (T4). *Oreochromis shiranus* fry weighing 1 g were randomly stocked in 1 × 1 × 1 m concrete tanks. Each treatment was replicated three times and randomised to minimise errors. The collected data included dissolved oxygen, pH, and temperature. Growth parameters were sampled fortnightly, and a total of eight samples were collected. The individual weight (g) and length (cm) of 30 fish per treatment were measured. Proximate analysis was performed at the Chancellor College laboratory in Zomba, Malawi, to determine the macronutrient values in each diet (Table 4).

The following calculations were made for growth performance: weight gain (WG) in g = final weight (g) -initial weight (g); specific growth rate (SGR) = LnW2 -LnW1/t (days), where Ln = the natural log; W1 = the initial fish weight in grams, W2 = the final fish weight in grams, and t = period in days; feed conversion ratio (FCR) = feed intake (g)/weight gain (g); and condition factor (CF) was calculated from the equation 100 W (g)/ L (cm) 3, where W= body weight and L= body length. The water parameters were measured daily using a multimeter. Water quality parameters, including pH, dissolved oxygen, and temperature, were also monitored. Fortnightly, 80% of the water was changed during the study period.

Data collected were subjected to a two-way analysis of variance (ANOVA) test using Microsoft Excel, and means were tested using the Tukey test at the 5% level of significance.

4.2 Objective 2: To map out and identify key players and analyse the aquaculture fish feed value chain in Malawi.

The value chain was mapped out using information from structured questionnaires and interviews with key players in the aquaculture sector, including the office of the Director of Fisheries, and by collecting secondary data from the literature. A total of four local fish feed producers who were in operation at the time of the study were interviewed, and five active registered fish feed importers were interviewed.

4.3 Objective 3: To perform a cost-benefit analysis to assess the sustainability of adopting either imported or domestically sourced feed.

Data collection for this analysis was conducted by tracing the feed value chains, administering open-ended questionnaires, and physically consulting current prices in the markets. A cost-benefit analysis (CBA) was conducted for two investments, classified as imports of fish feed from Zambia and local production of feed. Costs were based on existing market prices as of the April 2024 financial year. The US dollar exchange rate against the Malawi kwacha was pegged at MWK 1,694.92. The following criteria for the evaluation of CBA, adopted from Wambua (2015), were performed using the following formulas. The Net Present Value (NPV) was used to measure the present value of the net benefits of the two investments using the following formula:

$$NPV = \sum_{t=t_0}^{T} \frac{(B_t - C_t)}{(1+r)^{t-t_0}} = \sum_{t=t_0}^{T} \frac{B_t}{(1+r)^{t-t_0}} - \sum_{t=t_0}^{T} \frac{C_t}{(1+r)^{t-t_0}}$$

where Bt is the benefit at time period t, Ct is the cost at period t, T is the project period or terminal year (can be equal to infinity), and r is the discount rate.

Benefit–Cost Ratio (BCR) is the ratio of the present value of benefits to the present value of costs. The ratio determines the return per unit of investment made and is calculated as follows:

$$\text{BCR} = \sum_{t=t_0}^{T} \frac{B_t/(1+r)^{t-t_0}}{Ct/(1+r)^{t-t_0}}$$

where Bt is the benefit at time period t, Ct is the cost at period t, T is the project period or terminal year (can be equal to infinity), and r is the discount rate.

Internal Rate of Return (IRR) calculates the rate of discount that equates the present value of benefits with the present value of costs to determine whether the project is worthy of financial investment. IRR appears as the ‘unknown’ i as follows:

$$\sum_{t=t_0}^{T} \frac{B_t - C_t}{(1+i)^t} = 0$$

where Bt is the benefit at time period t, Ct is the cost at period t, T is the project period or terminal year (can be equal to infinity), and r is the discount rate.

5 RESULTS

5.1 Growth performance assessment

The results of the growth performance analysis are summarised in Table 1, and the growth curve, mean weight gain, SGR and Daily weight gain are illustrated in Figures 2-5.

Table 1: Summary of parameters measured for analysis of growth performance.

Parameter	**Treatment**			
	T1	**T2**	**T3**	**T4**
Avg weight gain (g)	12.28^{a} ±0.27	13.55^{a}±0.5	16.6^{b}±0.94	17.48^{b}±0.75
Daily weight gain (g day^{-1})	0.13^{a}±0.0036	0.14^{a}±0.0036	0.16^{b}±0.005	0.18^{b}±0.0073
SGR (% day^{-1})	5.67^{a}±0.0018	5.45^{a}±0.0018	5.47^{a}±0.001	5.47^{a}±0.0036
FCR	3.05^{b}±0.06	3.03^{b}±0.094	2.81^{a}±0.05	3.03^{b}±0.08
Condition factor (g cm^{-3})	1.32^{a}±0.035	1.46^{b}±0.054	1.39^{b}±0.05	1.53^{b}±0.06
Survival rate (%)	100	100	100	100

Values are means ± standard deviations. Values with the same superscript in a row are not significantly different. T1, T2, and T3 are locally produced commercial fish feed, while T4 is an imported commercial fish feed from Zambia.

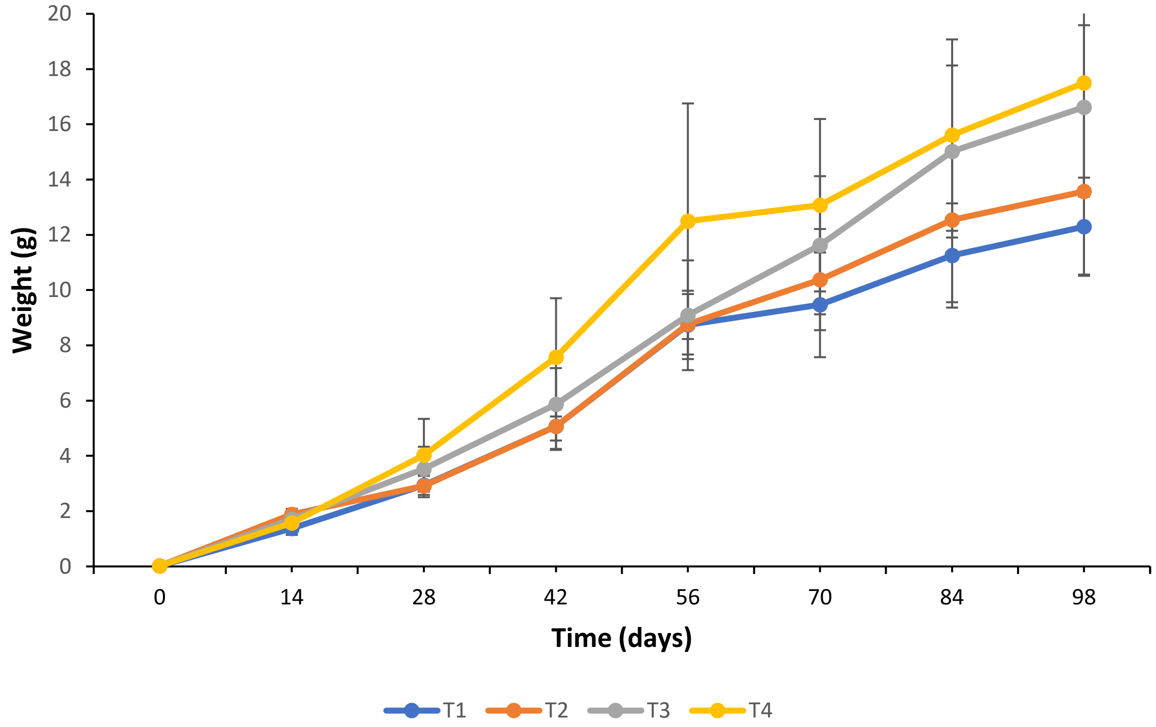


Figure 2: Mean weight gain (±SE) of *O. shiranus* fed on locally produced commercial fish feed (T1-T3) and imported commercial fish feed from Zambia (T4). The error bars indicate standard deviations of the mean values obtained.

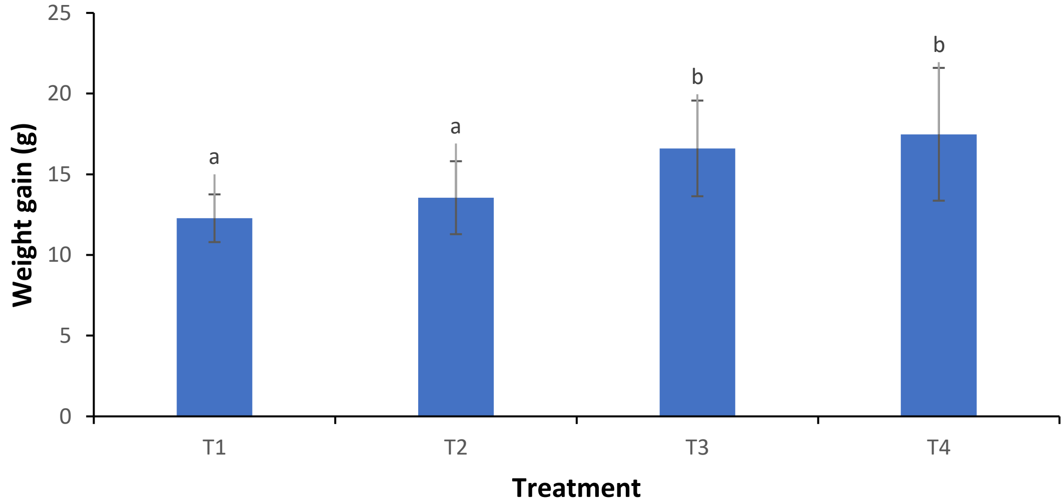


Figure 3: Weight gain of *O. shiranus* fed on locally produced commercial fish feed (T1-T3) and imported commercial fish feed from Zambia (T4). The values labelled with identical letters are not significantly different.

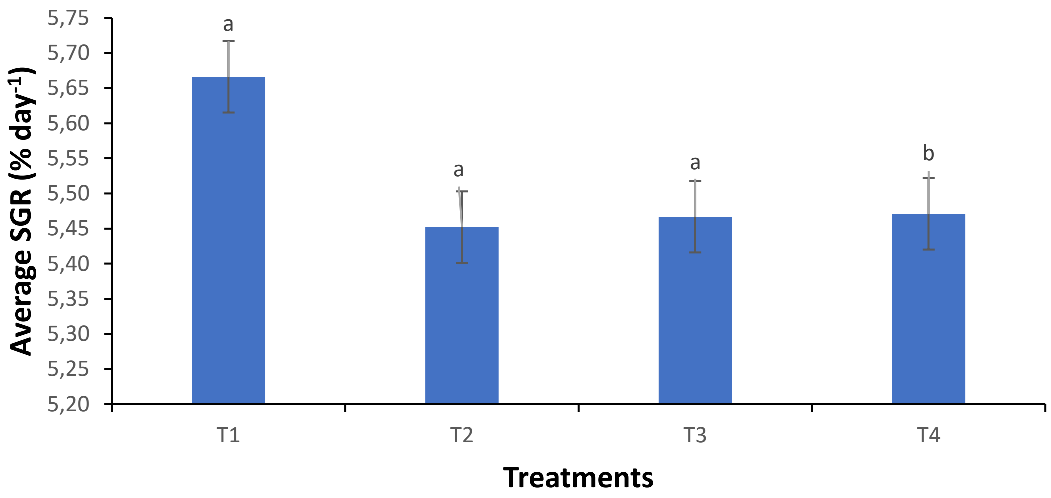


Figure 4: Average specific growth rate of *O. shiranus* fed on locally produced commercial fish feed (T1-T3) and imported commercial fish feed from Zambia (T4). Values labelled with identical letters are not significantly different.

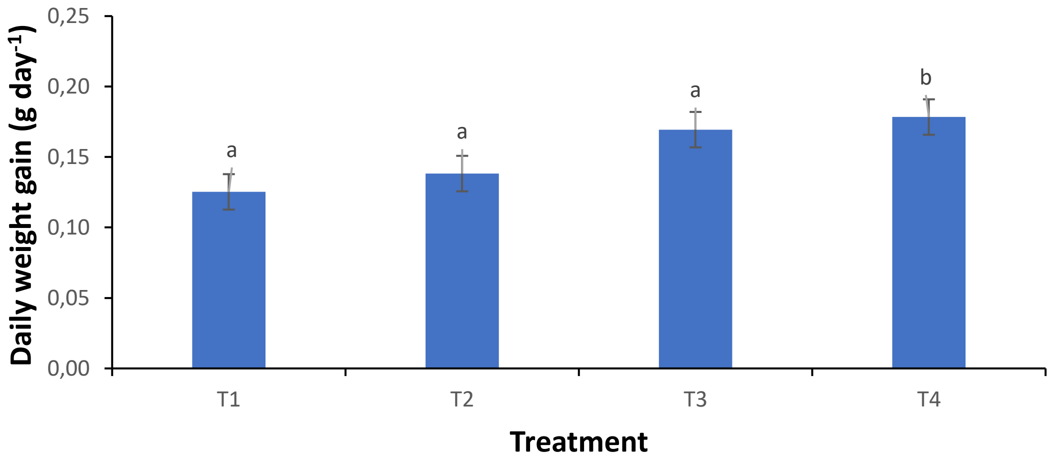


Figure 5: Daily weight gain of *O. shiranus* fed on locally produced commercial fish feed (T1-T3) and imported commercial fish feed from Zambia (T4). Values labelled with identical letters are not significantly different.

5.1.1 Feed conversion ratio.

The feed conversion ratio for T3 (2.81^{a}±0.05) was significantly different compared to diets T1 (3.05^{a}±0.06), T2 (3.03^{b}±0.094), and T4 (3.03^{b}±0.08) as illustrated in Figure 6.

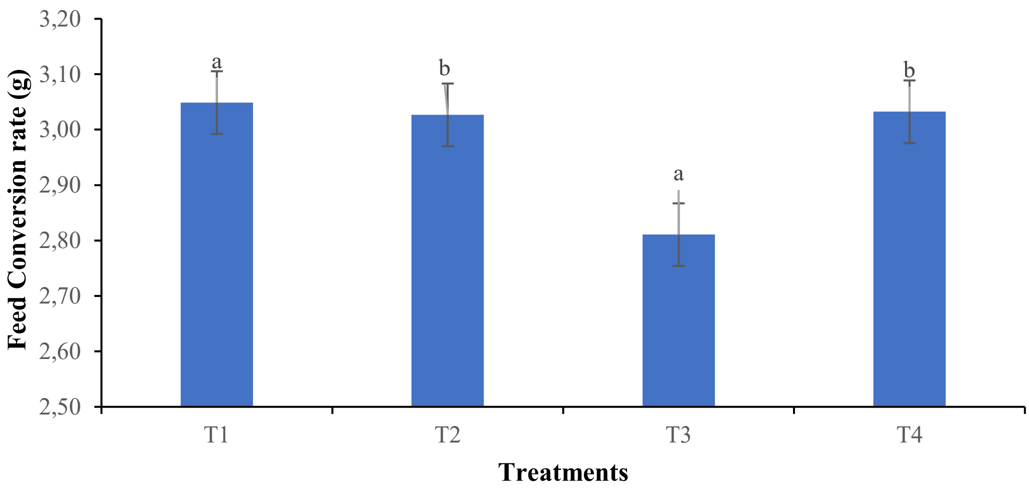


Figure 6: Feed conversion ratio of *O. shiranus* fed on locally produced commercial fish feed (T1-T3) and imported commercial fish feed from Zambia (T4). Values labelled with identical letters are not significantly different.

5.1.2 Condition factor

The conditional factors were classified according to Fulton's (1902) classification (Table 2). The K values illustrated in Figure 7 were as follows: T1 (1.32^{a}±0.035), T2 (1.46^{b}±0.054), T3 (1.39^{b}±0.05), T4 (1.53^{b}±0.06). According to the Fulton classification, all fish were in good health.

Table 2: Condition factors according to Fulton (1902) classification

K value	Comments	Symbol
	Excellent condition trophy class fish	Ex
	A good, well- proportioned fish	G
	A fair fish, acceptable to many anglers	F
	A poor fish, long and thin	P
	Extremely poor fish, resembling a barracuda, big head and narrow, thin body	EP

Source: (Momi and Islam, 2020)

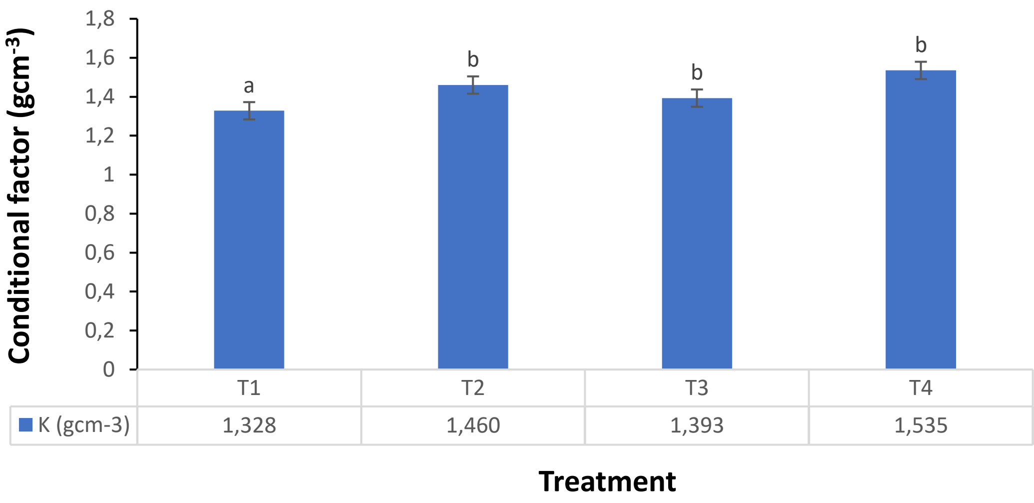


Figure 7: Condition factor (g mm^3) of *O.shiranus* fed on locally produced commercial fish feed (T1-T3) and imported commercial fish feed from Zambia (T4). Values labelled with identical letters are not significantly different.

5.2 Proximate analysis

The proximate analysis of the feed tested in the study is shown in Table 4.

Table 4: Proximate analysis of each fish feed composition. The composition (%) of locally produced commercial fish feeds (T1-T3) and imported commercial fish feed from Zambia (T4) is shown. Values labelled with identical letters are not significantly different.

Treatment	Composition (%)				
	Moisture	**Ash**	**Crude Fiber**	**Crude Protein**	**Fat**
1	13,17^a±0,04	4,95^a±0,11	8,11^a±0,17	40,15^a±0,25	2,9
2	13,85^a±0,03	6,49^a±0,08	8,93^a±0,17	45,21^a±0,30	0,36
3	11,18^a±0,05	17,3^b±0,08	8,93^a±0,21	32,8^a±0,27	2,24
4	11,69^a±0,75	6,97^a±0,41	8,53^a±0,38	42,43^a±0,14	2,15

5.3 Cost-benefit analysis (NPV, BCR, IRR)

A cost-benefit analysis (CBA) was conducted to determine whether investing in commercial feed imports is more profitable than producing commercial feed locally. Two scenarios were compared: importation of commercial feed and local feed production, both with an initial investment of $2000 and calculated over a three-year period (Table 5). Infrastructure and machinery investments were not considered for local feed production.

Table 5: Net present value, benefit-cost ratio and internal rate of return for commercial feed imports and local commercial feed production

Item	**Unit**	**Imported Feed**	**Local feed**
Net Present Value (NPV)	$	5,678.44	4,634.36
Benefit-cost ratio (BCR)		1: 1.04	1.44:1
Internal rate of return (IRR)	%	36	6

**NVP was calculated at 10% discount*

6 DISCUSSION

6.1 Growth performance

Feed is an expensive component of aquaculture production, and it is paramount and sustainable that the feed is efficiently utilised by fish to ensure maximum returns. The feed conversion ratio is used to calculate feed utilisation, which is a measure of feed quality. A lower feed conversion ratio of 1.5 or 2 is desired and indicates better feed utilisation in tilapia (Arifuzzaman, 2021). Weight gain significantly differed among the treatments from day 42 to 56 (Figure 2). For the final average weight gain and daily weight gain (Table 2), there were indications that T4 (imported) and T3 (local) were not significantly different, indicating that using either treatment would result in desirable weight gain. However, T3 exhibited a lower FCR than T4, suggesting that not all the nutrients invested in T4 were fully utilised by *O. shiranus* and converted into fresh weight. Based on the findings of this study, the use of T3 instead of T4 is more economically advantageous for farmers, as it helps achieve the same desired outcome at an affordable cost. Although these options may not offer the same nutritional quality or digestibility as the more expensive formulated diets of commercial companies, smallholders with limited production capacity can benefit from the cost-profit advantage.

The condition factor is an indicator of the variability associated with the growth coefficient and provides information on the feeding activity of a species to verify whether it is fully utilising the feed provided (Migiro et al., 2014). The condition factor values were not significantly different between the treatments (Table 2). In addition, the fish in all treatments exhibited excellent condition, indicating that their health was not affected by other parameters in the environment.

T3 provided the lowest feed conversion ratio (FCR) (2.81±0.052) compared to the other diets, whose FCRs were above the recommended range for tilapia (Table 2, Figure 6). The FCR of T1, T2, and T4 were slightly above the recommended range, indicating that the feeds were not fully utilised by *O. shiranus*. In the case of T4 which was an imported feed, this could indicate that the feed did not fully meet the nutritional requirements of the fish. The T1 and T2 FCRs were higher, potentially because of the higher quality of locally manufactured components. Munthali et al. (2022) reported that *O. shiranus* has a slower growth rate and feed consumption. A higher FRC indicates that the investment is lost because the nutrients paid for in the feed are not fully converted to fish flesh. Hambloch and Hülsebusch-Keello (2021) in their study outlined that there is no capacitation in the quality standards in Malawi at the point of production. Producers, traders, and processors must understand consumers' quality expectations and organise the supply of high-quality products with the help of the Malawi Bureau of Standards to ensure adherence to minimum grades and quality standards.

Given that feed formulation is a primary cost in fish culture, it is important to ensure that it is of good quality and meets the nutritional requirements of the fish (Manam, 2023). The nutritional composition (Table 4) of four feeds; three locally produced (T1, T2, and T3) and one imported feed (T4); were analysed using Weende´s proximate analysis. The moisture content in the samples ranged between 11.18 ±0.05 to 13.17 ±0.04 for T1, T2 and T3. While T4 gave 11.69 ±0.75. No significant differences were observed in the moisture content of the feed. The recommended moisture content for feed is in the range of 5 and 10%, while feed that exceeds 13% moisture is prone to have a short shelf life (Dawodu et al., 2012). T3 had a moisture content of 13%, meaning that it was vulnerable to spoilage, making its shelf life shorter than that of the other diets.

The ash content in the feed represents the mineral composition of the feed, which is important for maintaining physiological processes in fish. The ash content was abnormally higher in T3 (17.3 ± 0.08), while T1, T2, and T3 ranged from 4.95±0.11, 6.97±0.08, and 6.97±0.41, respectively. T3 exhibited a high ash content, which could be due to several factors, including the fishmeal used in the formulation, which had a high concentration of bone. On the other hand, the feed formulation of T3 included mineral fish premix, mono calcium phosphate, lysine, lime, and methionine, and the inclusion of these ingredients apart from the fishmeal may have contributed to the high ash content. Extra mineral premixes help compensate for any potential mineral deficiencies due to reduced bioavailability, which may occur when using plant-based sources in feed preparation (Mjoun et al., 2010).

Dietary fat is an alternative energy source to carbohydrates and proteins. All treatments had low fat content, ranging from 2.9 % (T1), 0.36 % (T2), 2.24 % (T3), and 2.15 % (T4). Tilapia fat requirements range from a minimum of 5%, whereas diets containing 10% to 15% lipids have been shown to improve growth and intake of protein efficiency (FAO, 2024).

Dietary protein is an essential factor in feed formulation, as it affects the growth, health, and feed cost of fish. Zablon et al. (2020) found that the condition factors of juvenile *O. niloticus* were 1.7 in conditions of varying protein levels between 22-35%, indicating that reducing the protein levels of the feeds can be economical. This may explain why T3, despite having low protein levels compared to the other treatments, still resulted in a high growth rate. Tilapia crude protein requirement in fry to juvenile stages ranges from 45 to 35 % (FAO, 2024). This indicates no significant difference in the crude protein, ash content, fibre, fat, or moisture content across the treatments.

6.2 Mapping and analysing the Malawi fish feed value chain.

The fish feed value chain was mapped and analysed by utilising cost data from actors at each stage and linking the functions of each key player to the value chain. The fish feed value chain in Malawi is a combination of local feed mill producers and imported fish feed, mainly from Zambia, as illustrated in Figure 8. The main key players were identified in terms of their functions as follows.

1. Feed input suppliers who mainly supply both imported and locally sourced farm raw materials. This includes Argo farmers who sell produce at farm gate prices, Argo retailers who resell farm produce and import additives, and other raw materials (fish meal, wheat flour, and bran). This category also includes fish traders who buy and process fish on the beach. They resell the leftover dried fish as fish meal for animal feed.
2. Fish feed producers include three government-owned mills and seven private mills, of which two were in full operation at the time of this study, while the others were still in their establishment stage.
3. Fish feed importers that buy feed from abroad (Zambia) and resell it to farmers, government farms, and NGO projects.
4. Fish farmers that buy the feed for farm use.
5. The Office of the Director of Fisheries coordinates and regulates value chain activities in terms of policies, strategies, and management.

The relevant regulatory authority for the fisheries and aquaculture industry is the Department of Fisheries of the Ministry of Natural Resources and Climate Change. The Department, through the office of the DOF, works with development partners (NGOs) to address training needs and publish materials to guide and manage the sector. The Malawi Bureau of Standards is the regulatory body for quality control, development of standards, import and export tariffs, and protection of citizens from unsafe food, working in conjunction with the Department of Livestock.

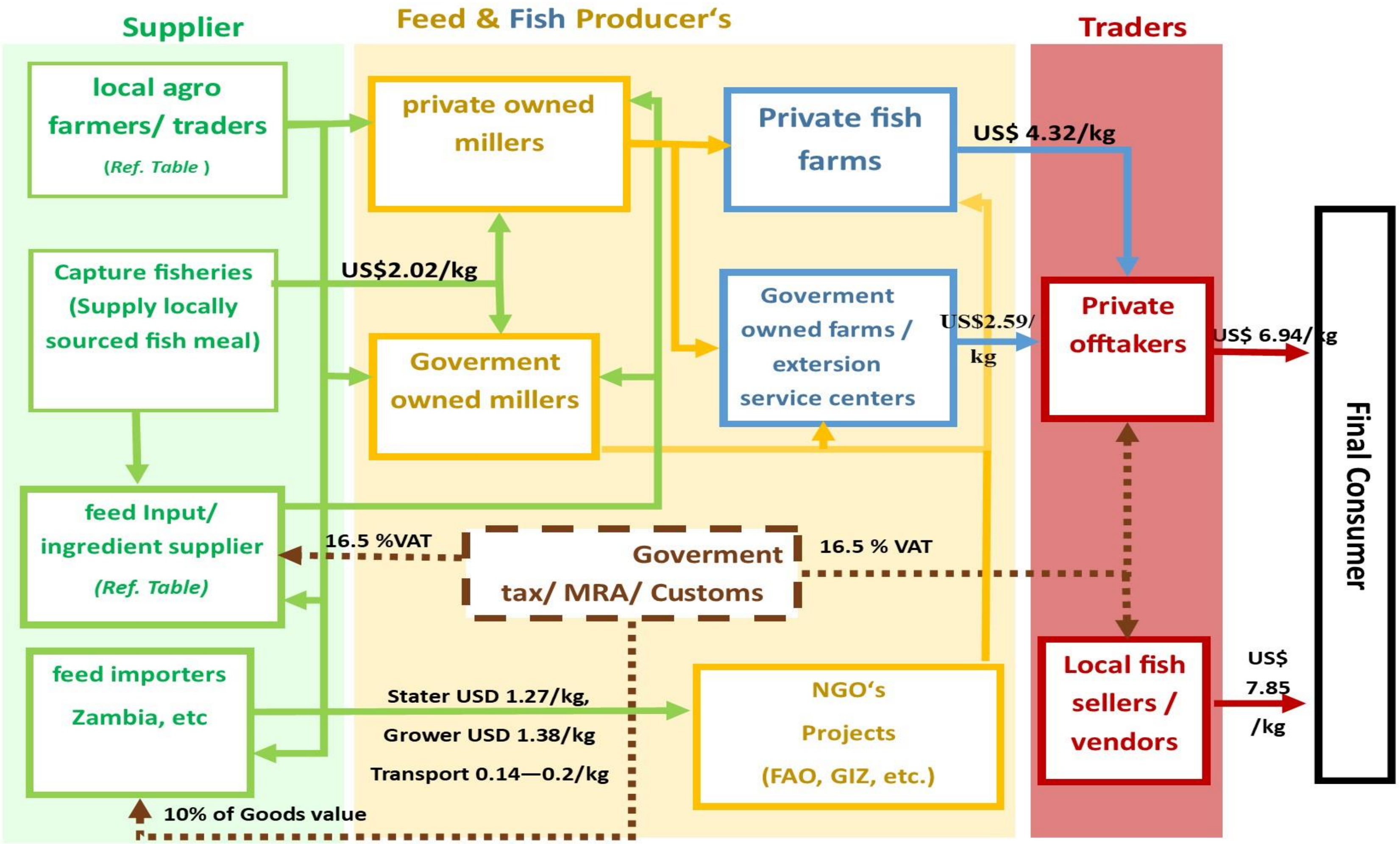


Figure 8: Fish feed value chain in Malawi.
The arrow direction indicates where the commodity is supplied. Green Zone/arrows indicate the movement of inputs (raw materials, fishmeal, vitamins, minerals, and imported commercial feed. Yellow Zone/arrows indicate fish and feed producers, feed production products are represented by yellow arrows, and farm fresh fish products in blue. Red zones are traders who resell fresh fish from fish producers to final consumers. Brown dotted line denotes the government authorities responsible for revenue, tax, and customs. Black box is the final consumer.

The main players in providing raw materials are local agriculture farmers, producing approximately 80% of the ingredients used in feed formulation. Feed raw materials are locally available in Malawi because agriculture serves as the cornerstone of the economy, contributing approximately 32% to the GDP (MoE, 2024). Sunflower seed cake, cotton seed cake, soybean, low-fat soybean cake, and groundnut seed cake are locally accessible plant protein sources that are employed as novel feed additives in Malawi. These seed cakes are mostly by-products from oil extraction, and the by-products are resold by retail Argo dealers (Table 4 in the appendix). The inclusion quantities of ingredients differ based on factors such as the protein and energy compositions of the feed, ingredient availability and prices, and the fish species and life stage (Jauncey, 2000).

Fish meal is the determining factor in the cost of feed, as most of the fish meal used in the formulation is imported into the country at US$ 3.47 per kg and the one from capture fisheries bought from fish off-takers is bought at US$ 2.02 per kg (exchange rate as of April 2024 financial year). Locally sourced fish meal is often of low quality and cheaper because of the mixture of small pelagic species and non-edible impurities that reduce quality and give varying crude protein content. However, fish meal does not undergo proper processing before grinding into fish powder. On the other hand, imported fish meal is of good quality however it was discovered from the questionnaires that it comes with impurities such as metal and plastics. These cause damage to machinery if not properly isolated, and there is no traceability on the source of the fishmeal, which is a biosecurity hazard considering that there is an outbreak of diseases that can be passed on through this medium.

Malawi has yet to establish fish feed standards, regulations, and certification to avoid low-quality feed inputs flooding the market which puts farmers at a disadvantage (Mwema et al., 2021). Regulators will use these standards to define a clear definition of the minimum parameters to be used as a benchmark for feed quality certification.

With the fluctuation of the Malawian Kwacha against major currencies, the prices of feed ingredients and processed feeds keep on increasing substantially which is not sustainable for the industry. Regulating local fish meal quality, together with specifying its nutritious content, will aid in reducing feed prices and be a step towards attaining sustainability because it is locally supplied. On the other hand, feed additives such as vitamins and mineral premixes (Table 6) are bought directly from Agro-retailer shops that import into the country and are put at an inclusion rate varied between 0.5-1% of the formula.

Based on the results of the present study, the development of a regulation that ensures that feeds sold in the market are species-specific to achieve better feed efficiency is recommended. It was also recognised that even the feed imported into the country is not species-specific enough to address the nutritional requirements of the species being cultured. The DOF office, through its research centres, can enable comprehensive nutritional profiling of feed ingredients sourced domestically, as well as of all commercially cultivated aquaculture species. Manam (2023) demonstrated that achieving sustainability, optimal growth, and reduction of pollution in the environment is dependent on the knowledge of the feeding behaviour and amount of nutrients required by the species.

6.2.1 Feed producers

In Malawi, fish feed is manufactured by both government-owned mills and private investors. During this research, one out of the three state-owned feed mills was actively producing for its own farm use and selling on demand to farmers. Additionally, two out of six privately owned feed mills were engaged in commercial production and sales. The primary focus of producers is to produce tilapia feeds, despite African catfish (*Clarias garapinus*) also possessing commercial potential. All producers produce extruded floating feeds. The production capacity of both government-owned and private mills ranged from approximately 1.33 to 3 tons per day. The feed is repackaged from 5 kg to 25 kg. However, the research team could not obtain sufficient information on investment, especially capital investment, from the interviewed feed millers.

Local producers' access to customers is a challenge as the market is dominantly monopolised by feed imports. Information collected on feed prices from local producers varied; for example, private producers sell starter feed at US$ 0.69 - 0.87 per kg, while government-owned millers don't have an established price but resort at selling the same at US$ 0.52 per kg. Fish meal which is the main protein source for feed production, is sourced from two sources, directly from capture fisheries traders and is bought at US$ 2.02 per kg. Input supplier supply and resell both imported and locally sourced fish meal at US$ 3.46 per kg and US$ 2.31 per kg, respectively.

The private producers lamented that the government millers sell the feed at low prices which is unfair to the growth of their establishments. In their opinion it is for the best that the role of each player in the value chain is clearly defined. For instance, government-owned millers should stick to their role as extension service providers and demonstration centres to pave the way for investors to compete fairly. The Office of the Director of Fisheries might consider examining the regulation of feed expenses, similar to how the Ministry of Agriculture oversees the pricing of agricultural products and enforces penalties for non-compliance, aiming to create a fair economic environment.

6.2.2 Fish imports

Four importers participated in this study, and all of them were registered with the DOF office. The DOF office provides a letter of support to access import permits and bridges the gap between importers and potential customers, mostly development partners, through their projects. The initial investment capital for all the interviewees was sourced from personal funds and loans from banks, ranging from US$ 3,000 to US$ 4,500. Fish feed at the point of production in Zambia ranges from US$ 12 to US$23 (US$ 0.48-0.92 per kg), depending on the type of feed (starter, grower, or finisher) purchased. The only mode of transport is by road, and its cost varies depending on the tonnage, ranging between US$ 3.5 to US$ 5 per bag (US$ 0.14 -0.2 per kg). Prior to being sold, the feed undergoes repackaging at the warehouse from 40 kg bags to 5 and 10 kg bags for customers that want smaller packages. The ultimate retail prices are US$ 1.27 per kg for starter feed and US$ 1.38 per kg for the other feed types. Purchases are made in cash, and short-term credit is given to certain customers. The pricing per kg within the imported feed value chain is similar. One hundred percent of feed distribution shops are situated in major towns and cities, posing a challenge in terms of access to feed. Similarly, the same challenge applies to government-owned mills, as their production is demand-driven.

6.2.3 Fish farmers and consumers

There are approximately 17,012 fish farmers with a total of 11,000 ponds, covering a total pond area of 276.15 ha countrywide (MoA, 2024). A survey by Munthali et al. (2022) outlined that farms in Malawi are mostly small-scale, where an average of 27.3% of the fish produced is for home consumption, 60.1% is sold, 11.8% is gifted, and the remaining 0.7% succumb to postharvest losses. The fish were most often sold to customers at the farm-gate (by 65.6% of the fish farms) or in village or rural markets (40.7%), while it was less common to sell to traders who came to the village (20.9%) or to sell through other market channels (Munthali et al., 2022). The 2023 annual economic report states that farm-gate sale of fish yields an approximate total of US$ 45 million annually, translating to a gross revenue of US$ 24.5 million from aquaculture and an additional US$ 22 million from value addition (MoE, 2024).

In the present project, it was observed that government-owned farms sell their fish at a farm-gate price of US$2.59 per kg, while private farmers predominantly sell both at farm-gate US$4.32 per kg and through large supermarkets, where they sell their products on commission at a retail price of US$6.94 per kg. Price progression along the value chain indicates a trajectory from input producers to final consumers. Table 4 outlines the marketing channels used by small-scale fish farmers.

Table 3: Marketing channels used for small-scale fish sales.

Marketing channels	% of farms
Direct to consumers (pondside)	65.6
Direct to consumers in a rural market	40.7
Traders that come to the village	20.9
Traders outside the village	12.4
Direct to customers in another setting	6.4
Direct to customers in urban market	5.1
Direct to customers by the road	4.1
Processors/wholesalers	2.4
Contract market	0.4

Source: Munthali et al. (2022).

6.3 Cost-benefit analysis

Wambua (2015) describes an economically viable project as one with a positive NPV, signifying that all monetary costs and benefits yield a net economic gain. Thus, when presented with multiple options, the option with the highest NPV is preferred, whereas projects with negative NPVs are deemed economically unviable. In this present study, both ventures were found economically feasible, however, the importing feed gave a higher NPV of US$ 5,678.44 compared to locally produced feed giving a NPV of US$ 4,634,36.

If a project's calculated BCR exceeds 1.0, it is expected to yield a positive net present value, suggesting that the benefits of the project outweigh its costs and warrant further evaluations. In this analysis, the BCR for feed imports from Zambia was 1.0, whereas that for locally produced feed was 1.44, indicating a higher value. Countries such as Zambia and Egypt have recorded remarkable growth in commercial aquaculture production of tilapia in recent years, attributed to local feed production subsidising the production cost. Therefore, it can be concluded from the BCR value obtained in the present study that investing in local production can help subsidise production costs to increase output and ensure sustainability.

The Internal Return on Return (IRR) for importing feed was calculated to be 36% and 6% if the feed was produced locally. Therefore, based on the NPV, BCR, and IRR, investment decisions favour importing feed as it provides a higher return than locally produced feed. Importing fish feed presents an advantage in accessing quality commercial feed, but on the other hand, actors in the local value chain will be crippled financially. In contrast, investing in local feed production presents higher benefits in terms of more players in the value chain, which will support the advancement and sustainability of the aquaculture sector in Malawi.

7 CONCLUSIONS AND RECOMMENDATIONS

In conclusion, considering the instability of the forex market in the country, it is crucial to prioritise quality, efficiency, and cost-effectiveness for the sustainability of the aquaculture industry in Malawi.

The present study explored the implications of utilising locally produced fish feed compared to commercial fish feed imports on the sustainability of the aquaculture industry in Malawi, and the obtained results led to the following recommendations:

- Analysis of the fish feed value chain identified a high dependence on fish meal imports compared to locally sourced fish meal which is of lower quality. It was also observed that the raw material imports contained impurities that needed to be sorted out before use. This indicates that proper follow-up channels for feed ingredient suppliers are lacking, and both producers and commercial feed imports need to be checked and their product quality validated.
- Policies need to be considered with respect to reducing customs tariffs incurred when importing raw materials such as fish meal.
- The roles of each player in the value chain must be clearly defined. For example, government feed mills and farms produce and sell at lower prices, thereby creating an unfair business environment for private investors.
- No significant differences were observed in the growth performance of *O. shiranus* fed imported and locally produced feeds. Based on these findings, it is recommended that the government, through the office of DOF, resolve the challenges highlighted in this paper and invest in promoting existing local fish feed producers to ensure the long-term economic sustainability of the aquaculture sector.
- The results of the cost-benefit analysis indicate that the local feed production venture has the potential to be profitable and presents more social benefits to the country. However, a more comprehensive cost-benefit analysis involving all stakeholders is required.

REFERENCES

Arifuzzaman, M. H. (2021). An experiment on growth performance, specific growth rate (SGR) and feed conversion ratio (FCR) of rohu (*Labeo rohita*) and tilapia (*Oreochromis spp.*). *International Journal of Aquaculture and Fisheries Science, 7*(4), 35–41.

Dawodu, M. O., Olutona, G. O., Ajani, F., & Bello-Olusoji, O. A. (2012). *Determination of Mineral Trace Element and Proximate Analysis of Fish Feed*. FOOD ©2012 Global Science Books.

Department of Fisheries. (2016). *National fisheries and aquaculture policy*. Government of Malawi Press

Department of Fisheries. (2019). *Environmental and Social Management Framework: SFAD Project executive summary.*

Department of Fisheries. (2021). *National aquaculture strategic plan (2021–2031).* Department of Fisheries, Lilongwe.

Department of Fisheries. (2023). *Annual aquaculture performance report 2023*. Ministry of Natural Resources and Climate Change. (Unpublished report).

FAO. (2024). *Nile tilapia - Nutritional requirements*. Retrieved from https://www.fao.org/fishery/affris/species-profiles/nile-tilapia/nutritional-requirements/en/

Fulton, T. W. (1902). *Rate of growth of sea fishes*. Scientific Investigations, Fishery Board of Scotland, 20.

Froese, R., & Pauly, D. (Eds.). (2023). *Oreochromis shiranus*. FishBase. Retrieved February 4, 2024, from https://www.fishbase.se/summary/Oreochromis-shiranus.html

Hambloch, C., & Hülsebusch-Keello, S. (2021). *Livestock for food and nutrition security in Malawi: Policy gaps, needs and opportunities*

Jauncey, K. (2000). Nutritional requirements. *Springer*. doi:https://doi.org/10.1007/978-94-011-4008-9_9

Land O'Lakes International Development. (2016). *Feasibility study: Commercialisation of the feed and fingerling supply chains for the smallholder industry in Malawi*.

Landell Mills. (2016). *Commercialising the aquaculture sector in Malawi*. AgriTT Programme / DFID.
🔗 https://www.landell-mills.com/resources/files/CommercialisingtheaquaculturesectorinMalawi.pdf

Manam, V. K. (2023). Fish feed nutrition and its management in aquaculture. *International Journal of Fisheries and Aquatic Studies*.

Munthali, M. G., Chilora, L., Nyirenda, Z., Salonga, D., Wineman, A., & Muyanga, M. (2022). *Challenges and opportunities for small-scale aquaculture development in Malawi*. MwAPATA Institute.

Migiro, K. E., Ogello, E. O., & Munguti, J. M. (2014). *The length-weight relationship and condition factor of Nile tilapia (Oreochromis niloticus L.) broodstock at Kegati Aquaculture Research Station, Kisii, Kenya*. International Journal of Advanced Research, 2(5), 777–782.

Ministry of Agriculture (MoA). (2024). *Annual Aquaculture Production and Farmer Registration Report*. Government of Malawi. [Unpublished internal report].

Ministry of Economic Affairs. (2024). *Annual economic report 2024*. Department of Finance and Economic Planning

Mjoun, K., Rosentrater, K., & and Brown, M. L. (2010). *Tilapia: Environmental Biology and nutritional requirements.* South Dakota: SDSU Extension. Retrieved from http://openprairie.sdstate.edu/extension_fact/164

Momi, M. M. A., & Islam, M. S. (2020). *Condition factors: A health indicator for cultivable fishes*. Poster presented at the 1st NSTU Science Fiesta, Noakhali Science and Technology University, Bangladesh.

Mwema, C. M., Mudege, N. N., Lundeba, M., Nankwenya, B., Kakwasha, K., Phiri, M., Basiita, R. K., & Siamudaala, V. (2021). *A review of aquafeed business models and the feed value chain in Zambia and Malawi* (Program Report: 2021-08). WorldFish.

NASP. National Action Plan. Department of Fisheries. (2021). *National Aquaculture Strategic Plan (2021–2031).* Government of Malawi: Lilongwe.

National Planning Commission. (2020). *Malawi 2063 vision: Transforming our nation*. National Planning Commission.

SADC Secretariat. (2016). *SADC Regional Aquaculture Strategy and Action Plan (2016-2026).*

SARNISSA. (2021). *Sarnissa Aquaculture policy brief.* Quito-Ecuador: Zonacuario.

Tran, N., Peart, J., Rodriguez, U. P., Chan, C. Y., Hoong, Y., Siamudaala, V., Njaya, F., & Kafakoma, R. (2022). *The future of fish supply-demand in Malawi and its implications for nutrition security and poverty reduction* (Working Paper: 2022-21). WorldFish.

Wambua, M. M. (2015). *A cost-benefit analysis of the fish farming enterprise productivity program project in kenya. The case of implementation of the aquaculture development component in Meru country.* Iceland: United Nations University Fisheries Training. Retrieved from http://www.unuftp.is/static/fellows/document/moses15prf.pd

Zablon, W. O., Getabu, A., Ogello, E. O., Omweno, J. O., & Outa, N. (2020). *Condition factor of Nile tilapia, Oreochromis niloticus fry under the influence of different protein levels in a biofloc system*. International Journal of Advanced Research, 8(12), 25–34. https://doi.org/10.21474/IJAR01/12122

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APPENDICES

Table 4: List of ingredients and retail prices in Agro shops for 2023/2024

Ingredient	**Price (USD/kg)**
Crushed maize	0.52
Maize bran	0.22
Rice bran	0.098
Wheat bran	0.22
Wheat flour	0.72
Vitamine premix	3.73
Mineral premix	3.73
Soya bean Full fat	0.48
Low fat soya	0.43
Fish meal (imported)	3.45
Fish meal (local)	2.01
Salt	0.4
Vegetable oil	1.28
Cassava flour	0.26
Sunflower seed cake	0.30
Dicalcium phosphate	2.58
Mono Calcium Phosphate	1.95
Methionine	4.31
Lysine	3.16

Table 5: Strategic crops gate prices for the 2023/24 season

Crop	**Minimum price (US$ / kg)**
Maize bran	0.22
Soya bean	0.46
Groundnuts	0.69
Sunflower	0.38
Cassava - wet	0.26
Cotton	0.52
Rice	0.38

Source: Ministry of Agriculture Press release 2023/24

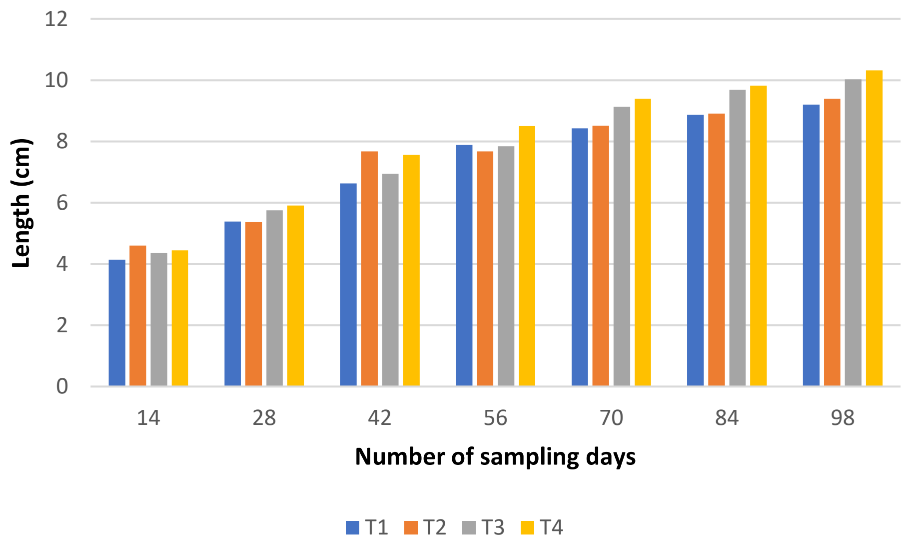

Figure 8 : Weight gain of *O.shiranus* fed on locally produced and imported fish feed.