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Feasibility Study:

Commercialisation of the Feed and Fingerling Supply Chains for the Smallholder Aquaculture Industry in Malawi

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UMODZI
CONSULTING

Prepared for:
Landell Mills: Development Consultants

Prepared by:
Imani Enterprise Ltd
Umodzi Consulting
University of Stirling

PROJECT CONTACT

Name of Contact	Iain Gatward, Imani Enterprise Ltd
Position	Director
Address	Imani Enterprise Ltd St. Moluag's Diocesan Centre, Croft Avenue Oban Argyll PA34 5JJ
Tel No:	01631 569990
E-mail:	iain@imanidevelopment.com

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1. EXECUTIVE SUMMARY

Malawi has a long history of aquaculture, with over a century of various indigenous species being reared for a range of different markets. However, in recent times production has focussed towards local tilapias and more specially *Chambo* species from the genus's *Oreochromis* and *Tilapia*. Over the last 40 years, a series of donor funded development projects have sought to develop and increase production through smallholder aquaculture in earthen ponds, both as a means of improving household income but also crucially, community and more specifically household nutrition. Despite these ongoing interventions, the lack of commercial inputs in supply chain development has been flagged as one of the main limiting growth factors for the sector. More specifically, the supply chains of suitable fish feed and fingerlings require significant improvement and development.

Funded by the UK Department for International Development (DfID), the Working in Partnership for Agricultural Technology Transfer Project (AgriTT), under the Malawi Pilot Development Project (PDP), aimed to form a collaboration between multiple actors seeking to secure sustainable expansion of the country's tilapia aquaculture sector. AgriTT has sought to facilitate the transfer of relevant Chinese technologies in attempts to achieve production and productivity improvements. The project has been granted a one-year extension until March 2017 and during this period, particular focus will be on the sustainable commercialisation of production and strengthening of associated value chains for smallholder fish farmers.

The specific objective of this study, at the request of Landell Mills was to gain an understanding of the current profitability of smallholder aquaculture production, in order to discern and attempt to quantify the potential market for feed and fingerling supply chains and how the production and supply of these crucial inputs can be commercialised to fulfil the needs of these smallholder aquaculture producers. The project team employed a phased approach; including thorough analysis of available AgriTT datasets to inform a random selection process for smallholder case studies. Whilst key stakeholders within the supply sector were also engaged to identify issues relating to supply chains for both key inputs.

From interviews and data reviewed in this study, it appears likely that less than 20% of current smallholders practising aquaculture demonstrate financial viability to justify the use of commercial inputs and as much as 80% cannot demonstrate financial viability due to their personal circumstances, abilities, finances, or availability of support and inputs required. The lack of formal, domestic supply chains for feed and fingerlings at both the commercial or smallholder scale signals a need for change within the sector.

It is suggested from this study that the current lack of reliable, quality fingerlings is the major barrier to development within the sector, rather than the availability of high quality, formulated feed, since the growth potential of unimproved fish strains is suboptimal regardless of feed quality. It is therefore recommended that whilst feed development is still important, any future engagement by donors in the sector should focus on combatting the lack of quality fingerlings and the production and distribution of monosex fish for all outgrowers, to maximise fish production potential. Current producers from both the public and private sectors are not meeting demand due to a range of factors discussed and there is a need for further private sector investment on a larger scale, through the development of well-placed, mid and large-sized hatcheries to meet market demand. This development will in turn justify a requirement for high quality, formulated feeds and provide smallholders with a greater range of high end markets for their products, since they will be able to

consistently produce larger fish. Previous attempts to identify and empower mid-scale smallholders to become hatchery operators have not seen reliable results due to a number of reasons and although evidence exists to support the presence of fish farmer groups and networks, further efforts are required to connect individuals together for the procurement of key inputs.

Feed production is another essential component for commercial aquaculture development; however, high quality, formulated feeds are currently available through Zambian suppliers, who are certainly able to meet demand until such a time as a critical mass of production exists in Malawi; bringing products with relatively good quality at affordable prices, including transportation. The prices for feed produced domestically from Maldeco and those imported from Zambia are in the region of MK 30,000 per bag (40-50 Kg), which equate to approximately 0.8 USD per Kg at the time of writing this report. Interviews with Government Staff indicated that local feeds could be produced for closer to MW 16,000-20,000 per bag, which equates to approximately 0.5 USD per Kg at the time of writing this report. There is therefore some scope for supporting growth of locally produced feeds at reduced rates, but evidence is lacking to guarantee the production and distribution of these products. Many smallholders in Malawi using external, imported feeds are doing so through a subsidised programme, so it remains to be seen how many would continue with this type of expenditure as a stand-alone business. Once production is significant enough in Malawi, several producers / suppliers are ready and available to engage, however demand simply is not there at the current scale to make commercial supply a viable option. The alternative for many smallholders in Malawi is to continue use of basic, on-farm, supplementary feeds such as rice and maize bran, and to gear their production towards local, 'small fish' markets, an option that still offers opportunities for profitability under appropriate farm management conditions. Further barriers to development for smallholders include; inconsistent supplies of water throughout the year, insufficient seasonal water temperatures at certain times of the year to encourage optimal growth and a lack of business acumen in procuring key inputs, essential record keeping and sourcing the most lucrative markets.

Interviews and discussions also identified the need for greater support to the private sector at both the larger commercial scale and for smallholders through extension services. Government Research Centres have a key role to play in African aquaculture and developing improved strains and feed etc., but in many places this works well as a supporting / enabling body rather than being primary fingerling producers for smallholder farmers. In contrast to these Government and Academic research facilities, the current, larger, private sector farms must demonstrate a core focus towards profitability and will therefore drive production further through the development of more reliable input supply chains for feed and fingerlings, a process or strategy that is clearly demonstrated by the development of the sector in surrounding countries, i.e. Zambia, with larger farming companies not competing with, but benefiting smallholder producers.

2. INTRODUCTION

2.1 MALAWIAN AQUACULTURE

Approximately a quarter of Malawi's land area is occupied by lentic and perennial water bodies, most notably, lakes; Malawi, Chilwa and Malombe and various rivers, the largest being the Shire which flows out from Lake Malawi, through the southern region and joins the Zambezi River in Mozambique. Due to this abundance of water, capture fisheries and associated livelihoods have played a key role in sculpting the consumption and nutrition of significant numbers of the country's population, with fish representing a primary source of dietary protein for many communities[1]. It is estimated from available data that fish provides over 60% of the dietary animal protein intake of Malawians.[2] Due to the over-exploitation of remaining fisheries and with the current population of around 16.4 million set to increase over coming years, there has been a downward trend in per capita consumption of fish from 10-18 kg/capita/year to 6-8 kg/capita/year over the past 50 years. Furthermore, the decline in fish stocks has contributed to a rise in the market price of tilapia, or *Chambo.* With regard to the national nutrition status of Malawi, the FAO states that:

"*The nutritional status of the Malawian population remains critical. Although short-term interventions such as supplementation and fortification still need to be reinforced, investment in long-term food based strategies are needed*."[3]

Aquaculture has been practised in Malawi for over a century, with the introduction of *Onchorhynchus mykiss* (Rainbow Trout), into the high-elevation, cooler waters above Zomba during colonial times[4]. Moreover, it has been suggested that approximately 10-25 percent of the country's land area is suitable for warm-water aquaculture, predominately the culture of tilapias[5]. Production was expanded with various indigenous tilapine species during the 1950's through the formation of the government-run Domasi Research Centre, designed to facilitate improvements in the breeding and distribution of improved quality fingerlings. However, since these early developments, aquaculture production has failed to produce significant increases in yields, with cage culture actually recording a decline in production since the 1980's[6]. Over recent decades, a range of different primarily international NGO's and donor agencies have tried to implement aquaculture projects with limited success due to a range of key factors including lack of sufficient government extension services and limited availability of good quality fingerlings and feed (the latter two being the focus of this study). Historically the poor uptake of private sector aquaculture has resulted in a perception, among many lower income smallholders, that the risks of starting up small scale pond aquaculture are too great to invest their own resources in trying to achieve financial viability.

The most recent statistics available for fish farmers are from a census carried out by the National Aquaculture Centre (NAC) (2003) which proposed that 4,050 fish farmers own and use 9,500 fishponds, with an estimated annual yield of 800 tonnes; approximately 2 percent of the nation's total fish production[7]. More recent figures provided by Government staff suggest an increase in the number of individuals practising fish farming, although this cannot be supported by current data.

1 http://worldfishcenter.org/content/recommendation-domains-pond-aquaculture-country-case-study-development-and-status-2
2 http://www.ijbssnet.com/journals/Vol_4_No_2_February_2013/18.pdf
3 http://www.fao.org/ag/agn/nutrition/mwi_en.stm
4 www.cabi.org/gara/FullTextPDF/2009/20093195681.pdf
5 http://www.fao.org/fishery/countrysector/naso_malawi/en#tcN70176
6 http://www.thefishsite.com/articles/1059/cage-aquaculture-in-malawi/
7 NAC. 2003. NAC - Annual Report, 2002/2003. http://www.fao.org/fishery/countrysector/naso_malawi/en#tcN70176

The predominant cultured species include various tilapia species (*Oreochromis shiranus*, *Oreochromis karongae* and *Tilapia rendalli*), typically grown in low-input, polyculture systems, producing yields ranging between 750 and 1,200 kg/ha/year, representing annual incomes of US$ 1,363 per hectare per year (approximately US$ 25/farmer/year)[5].

The main constraints for Malawian aquaculture include: the growth potential of species permitted for culture (it is not permissible to farm Oreochromis niloticus in Malawi), the supply of quality fingerlings and feed, technical expertise, market linkages and access to suitable credit. Although there are several commercial feed and fingerlings suppliers in Malawi, challenges continue to arise for the access and regular supply of these inputs with regard to securing the right quantity, quality and species. It remains an ongoing challenge to secure supply of monosex, and even mixed sex fingerlings that are of uniform size and age for out grower farmers; with recurring cases of fingerlings supplied and sold varying significantly and potentially already reproducing at the time of stocking. When combined with limited understanding of grow-out procedures and husbandry, these factors can have considerable impacts on farm management, with early maturation and breeding resulting in excessive stocking densities and stunted growth. In addition, for small-scale fish farmers in rural locations the external costs for transport and inputs such as feed and fingerlings are a constant struggle. These farmers rarely have sufficient, if any, financial records to show whether pond-based production systems are financially viable and there is a need for extension services and training to educate farmers in budgeting and financial management prior to start of the grow-out cycle. High input costs are an issue for farmers who face capital vulnerability and have limited access to micro-credit loan systems – although access to these has increased in Malawi in recent years, work is still required to support farmers in this area in particular. Furthermore, although there is a consistent and regular demand for (food) fish of even smaller sizes across southern Malawi, organising sales and securing markets remains a challenge for existing fish farmers. Value chain linkages must be improved if more farmed fish are to reach the desired marketplace in significant volumes and of acceptable freshness in order to meet the nutritional needs of the country's population.

TABLE 1: CATEGORISING SCALES OF AQUACULTURE ENTERPRISES IN MALAWI

Category	Description
Smallholder Farm	Generally, <3 ponds each with area <500m^2, typically run by one household or family members without paid employees, limited access to quality inputs; feed, fingerlings, fertilisers and credit or loans, Harvests once per 1-2 years or at unstructured intervals in accordance with needs, sells all fish in home village, owns little or no associated aquaculture equipment, little to no record keeping / business planning for future.
Mid-scale Farm	Generally, >3 ponds each with area 400-1000 m^2, owned by individual or household but employs one or more staff, able to access and afford some commercial inputs; feeds, fingerlings and fertilisers, at this level may be able to access loans and credit, harvest fish at least once every 6-8 months, sells most of fish outside village for higher prices, some level of financial records and business planning, however often not comprehensive.
Large-scale Farm	>10 ponds each with area >1000m^2, owned by individual/s, household or business but with many paid employees, exclusive use of commercial inputs and probable on-site production, able to access loans and credit, harvests at least once every 6-8 months, sells all fish outside village and mostly in urban markets and supermarket chains with contracts to further value-chain stakeholders, comprehensive, often computerised records by multiple individuals, concrete business plans for expansion or retention.

2.2 A HISTORICAL PERSPECTIVE

"Against this shift in emphasis and perspective, and against a history of many failures in farming systems research and development in Africa, we have come here to discuss and to clarify future directions. This is very timely. Many countries in sub Saharan Africa are watching the progress being made here in Malawi. They can see some pointers towards success in smallholder aquaculture and integrated farming. But we will need more support to build upon this."

- **Roger Pullin 1994**

Above are the telling words of Roger Pullin, the eminent ICLARM aquaculture and fisheries scientist, given at an international workshop on Aquaculture Policy and Integrated Resource Management in Sub-Saharan (SS) Africa held in Zomba back in February 1994. It could be argued that since those days, now over 22 years ago, certain other SS African countries have moved on to develop their aquaculture as evidenced by their increasing and voluminous annual aquaculture production statistics; whilst in Malawi to many extents and purposes aquaculture has not, based on national production statistics. There had been many donor-funded projects and reports prior to this, and donors including World Fish Centre, FAO, JICA, ALCOM, World Vision, Oxfam, GIZ, DfID etc. have continued to develop projects in the sector up to the present day. When considering future interventions in Malawian aquaculture, it is therefore important to note some key lessons can be learnt from both the struggles in Malawi and the successes seen elsewhere in the region.

It is perhaps pertinent to begin with the key word in the title of the above 1994 workshop "Integrated". Many projects since the 1980's working to develop aquaculture in Malawi have been built on the cornerstone of promoting that original ICLARM Asian-based production model of crop and livestock integrated pond aquaculture at an artisanal, rural, livelihoods level for lower income people. The evidence base since tends to show that for a number of reasons these systems are rarely successful or financially viable in a Malawi and generally even SS African context.

The development of commercial aquaculture in countries such as Nigeria, Ghana, Zimbabwe and Zambia has largely been based on a more private sector, entrepreneur-led model. In these situations, the fish are grown in monocultures using formulated feeds, quality fingerlings (monosex for tilapia and typically *niloticus*) and importantly the farms are located in peri-urban areas with good access to lucrative post-harvest markets and a regular supply of key inputs, most notably feed and fertilisers. In Malawi, the findings of reports and experience of interviewees for this study indicate that is has been difficult to implement this private sector growth, however this appears to be changing as is indicated from more recent private sector developments such as the cage farm and hatchery in Chipoka and Chonona hatchery in Chikwawa and there remains significant potential for an emerging aquaculture sector.

Throughout SS Africa there are many projects which have started with the best intentions, but have not been able to sustain themselves once funding ends, resulting in the target fish farmers unable to maintain the operation long-term. Some key lessons have been learned from these projects over the years and are well documented, below is a summary of the lessons that could apply to Malawi based on available literature and findings of this study.

- From the initial proposal-writing stage it is important to have a **clear and realistic exit strategy** to specifically address the end of project funding when fish farmers are expected to be self-sufficient. By this time the project should ensure the farmer has affordable access to

feed, fertiliser and fingerlings, and ability to transport and sell their fish in higher value peri-urban markets.

- Take time to find and employ **key project staff and partner organisations** who have the necessary commercial and practical skillsets to work effectively with selected fish farmers across the value chain to obtain secure value for money results.
- Design a clear **criteria-based selection process** for fish farmers engaged in the project.
- Maintain **realistic target numbers** of farmers within finite project resources – a key issue in the past has been trying to engage too many farmers in one project.
- Where appropriate include **microfinance or credit provision** for fish farmers to cover initial formulated feed outlay (70% of total running costs) in the first few cycles of production in order to stimulate the development of the sector, but expect that not all of these farmers will succeed long term.
- It is important to be clear from the outset what the **target size is for pond aquaculture** development. This report goes on to highlight different categories of smallholders, which can include small back-garden earth ponds, but could also be multiple ponds and even 10+ ponds in some cases. The requirements for each of these farmer categories differ significantly, so identifying the target farmer group is essential early on as well as the different strategies to effectively support and work with them.
- Malawi is fortunate to have, at any one time, a range of projects and donors working in aquaculture development. At the proposal and implementation stages it is therefore important that project managers and funding coordinators are **aware of what aquaculture development is taking place** elsewhere in the country. Projects should actively engage with each other to develop mutually beneficial synergies and ensure optimal use of funds and resources.

2.3 AgriTT – Aims and Objectives

Funded by the UK Department for International Development (DfID), the Working in Partnership for Agricultural Technology Transfer (AgriTT), under the Malawi Pilot Development Project (PDP), aimed to form a collaboration between multiple actors seeking to secure sustainable expansion of the country's tilapia aquaculture sector. The AgriTT project sought to facilitate the transfer of relevant Chinese technologies in attempts to achieve production and productivity improvements. The project was granted a one-year extension until March 2017 and in this period, particular focus will be on the potential for sustainable commercialisation of production by smallholder fish farmers. The specific objective of this study is to gain an understanding of the current profitability of smallholder production and how the feed and fingerling supply chains can be commercialised to fulfil the needs of these producers.

3. METHODOLOGY AND APPROACH

A phased approach was taken in the implementation of this study as show in Figure 1 below:

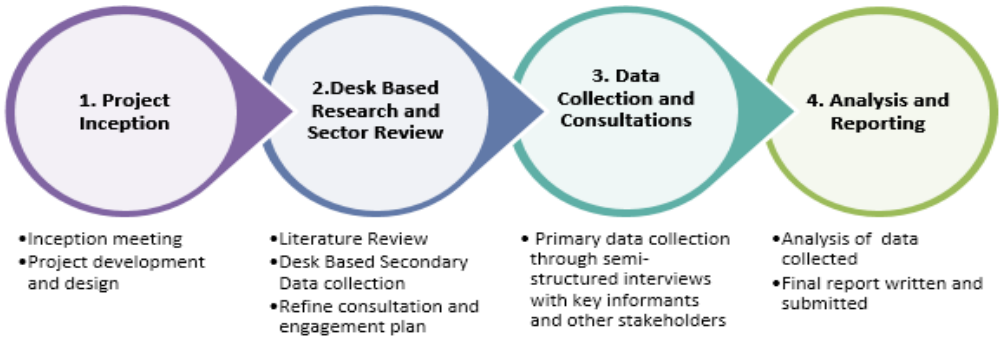


FIGURE 1. PHASED APPROACH TO THE STUDY'S MANAGEMENT AND DELIVERY

3.1 INCEPTION MEETING

An inception meeting took place between the consultants and the AgriTT country manager, Georgina Turner, to refine the study's plan and confirm activities as well as multiple calls within the wider project team in the UK and Malawi. These meetings provided an opportunity to discuss and confirm the study aims and the areas of research to be included.

3.2 DESK REVIEW

A review of data from AgriTT partners was combined with meetings with key staff to ensure the team could adequately identify gaps in the available data which would then be filled where possible through interviews with a sample of smallholders. The review sought to provide information on current production levels in Malawi and species available, highlighting associated constraints and successes. Initial productivity analysis was carried out on available AgriTT data of 100 smallholder farmers (particularly; data relating to overall productivity and economic feasibility, cost-benefit analyses of feed and other input use, purchasing of fingerlings and scale of farm). All smallholders were categorised by geographical location (regional; Central, Northern and Southern) and their potential viability for commercial input use. Smallholders were categorised into three key groups as follows:

1. **Viable for Commercial Inputs** - Entrepreneurial Individuals who demonstrate capacity and willingness to buy and use commercial feed of any type; domestic or imported. The use of technical practises such as fertilisation, liming and grading as well as sales and marketing activities providing further indication of commercial intent. Farms exhibiting approximately ≥1 ha total size, with reliable water supplies allowing for year-round production cycles.
2. **Potential viability for commercial inputs** – Like #1 but more specifically individuals who exhibit future potential, but for various reasons cannot commit to sole use of commercial inputs and still rely heavily on on-farm alternatives. Like #1, use of technical practises and sales planning indicate of commercial intent and scalability for production. Constraints attributed to insufficient land <1ha total size and consistent water availability.
3. **Commercial inputs not viable** - Those that are limited to use of on-farm feeds such as rice or maize bran exclusively (or combined with other inputs to form more complex recipes). Again, some of these will use fertilizer as well as other innovative management practises and others

will not. Farmers will not achieve optimal fish growth but through use of innovative regular marketing or value-addition can still make notable profits. Pond size typically ranges between <100m²-500m².

Three smallholders from each category were then randomly selected to obtain 9 individuals. Following this process, semi-structured interviews with each smallholder sought to confirm and elaborate on viability and likelihood to invest in commercial inputs, whilst also investigating examples of innovative alternatives which have potential to improve their financial viabilities (see Appendix 7.1).

Since aquaculture is practiced throughout Malawi it was important to consider how commercial farming could be supported throughout the country and where feed and fingerling production should be placed in future. Prior to the start of this project, the production of fingerlings in particular was flagged as a key issue, since proximity to market is a crucial factor i.e. juvenile fish cannot be transported over long distances in hot conditions and poor roads without resulting in considerable losses. This again relates to the aforementioned importance of looking to develop sustainable fingerling and feed production and supply in peri-urban areas. Whilst this may be less of an issue for feed production as the product is easier to transport, it still makes sense to locate feed mills in areas where locally-sourced agricultural and fisheries (fish meal) products can be utilised and where there is a relatively low cost for importing other feed ingredients not available in Malawi.

3.3 CONSULTATIONS

The aim of the methodology was to adopt a participatory approach and engage with both smallholders and other related stakeholders to assess the market capacity, demand, sustainability and possible models for the commercialisation of both feed and fingerlings supply chains. A semi-structured interview process was used, allowing participants to speak freely, but trying to ensure that the conversation included key themes. Key-informant interviews with AgriTT project and Government individuals were organised initially, to help design the on-going project activities and highlight key issues to be addressed in greater depth during the project's progression. Interviews were conducted in either English, Chichewa and Tumbuka, depending on location and the informant's preference.

A topic-guide of areas for discussion was developed during the initial scoping process with the team contacting all available stakeholders currently involved in the feed and fingerlings sectors to assess their opinions, current production levels, the issues and risks for them to engage with customers and how gaps in knowledge should be filled (see Appendix 7.2 and 7.3). Furthermore, prospective stakeholders who could become included within future growth were also included, to increase the validity of results. The aim was to assess key barriers to growth of commercial supply chains and the specific roles and support needed from key stakeholder categories including the Government of Malawi (GoM), the nascent private sector, external NGOs, donors and investors. An important consideration was reviewing whether commercial growth would be best supported through existing producers / suppliers, or whether there may be alternative investors who could be encouraged – either those already in Malawi or contributing from outside of the country.

For feed, it was deemed important to consider both in-country options as well options of encouraging Zambian feed producers such as Novatek. Although the ultimate aim should be to support growth of the industry in Malawi, it may be important to consider alternatives that could

see greater impact over a short-term as well as long-term investment opportunities. The study sought to challenge current thinking where required to ensure all options were considered and the strongest possible options are highlighted to support growth of the industry.

4. RESULTS

4.1 SMALLHOLDER AQUACULTURE IN MALAWI

4.1.1 CATEGORISING SMALLHOLDER FARMERS

The subcategories defined here describe different types of smallholder farmers as per table 1. It was quickly identified that the consistent procurement and use of commercialised inputs, such as formulated feeds is rare and limited to less than 10% of fish farmers since smallholders rarely do so through their personal funds alone and more regularly require assistance through subsidies; linked with NGO led projects. Historically, most smallholders have been given fingerlings and feed free of charge, either from NAC, Luanar or indirectly through Maldeco and via NGO support. Following the initial stocking through these mechanisms, there is a recurring theme among smallholders, whereby recruits (fry / fingerlings bred in the pond during production cycle) are recycled during cycles and placed in separate nursery ponds prior to restocking or, remain within grow-out ponds alongside the originally stocked population. Smallholders were placed into the following three categories; diagrams have been used to assist in demonstrating the conditions experienced by both extremes, although mid-level farmers experience elements of both;

1) Commercial viability and potential for acquisition of inputs

This category includes smallholders with higher levels of profitability and therefore a greater likelihood of accessing commercial supply chains. The farmers themselves often exhibit stronger technical and entrepreneurial skills than counterparts, demonstrated through a diversification of income generating activities ranging from property ownership to livestock rearing and horticulture, as well as articulated plans for expansion or improvement to optimise growing conditions in the future. This may come as a result of either; higher education, enabling a comprehensive understanding of financial records or entrepreneurial skills and business acumen leading to success

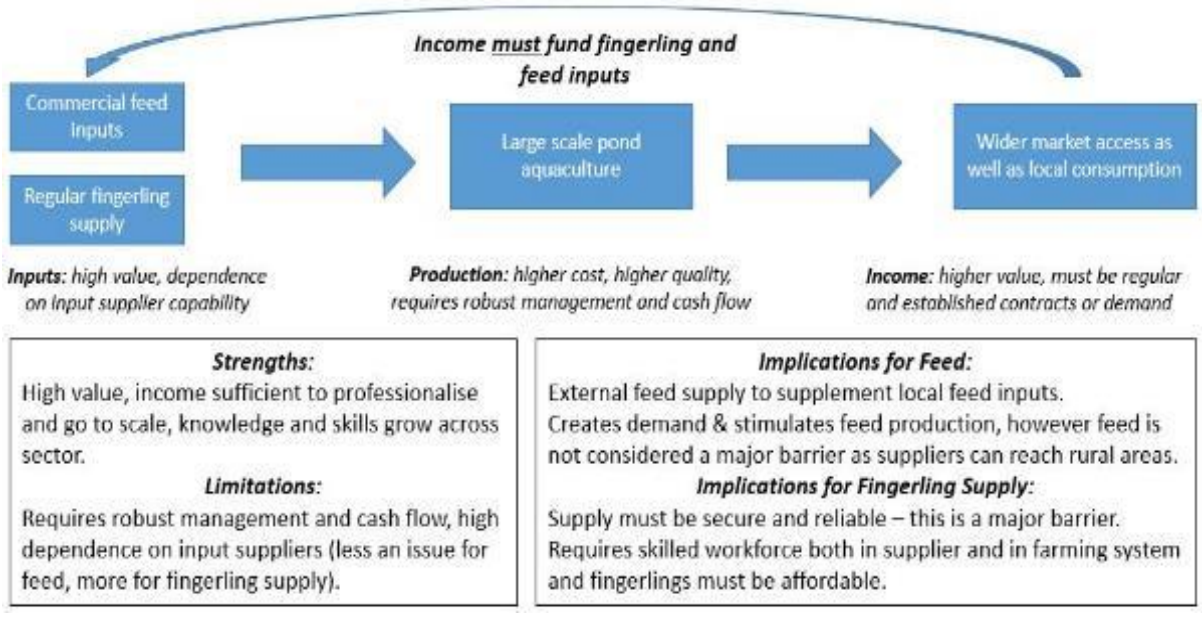


FIGURE 2: INDICATIVE PRODUCTION CYCLE FOR SMALLHOLDER USING COMMERCIAL INPUTS

from other business sectors. Additionally, whether through subsidy or self-finance these individuals can show demonstrable gains or evidence of benefit leading to a recurring passion for aquaculture and often well-articulated growth plans. Moreover, the crucial water demands for smallholders who fit within this category are typically served by either perennial waterbodies, streams or relatively reliable boreholes.

AgriTT smallholders in this category were provided with both fingerlings and feed free of charge, to conduct growth trials. Those with remaining feed bags after the trial continue to use until finished, but those with insufficient amounts for a full cycle reverted to either supplementary feeds or rudimentary on-farm formulations, using locally sourced ingredients. Recurring constraints to production arise in the form of limited access to quality inputs and smallholders being restricted by proximity to hatcheries for fingerlings. The poor availability and quality of seed is compounded further by the species available and associated poor growth rates, leading to suboptimal production, rising Feed Conversion Ratios (FCRs) and inbreeding. As shown though Gross Profit Analysis (see Appendix), the smallholders consulted in this category exhibited a positive Gross Margin when the cost of further pond expansion is excluded (GPM 5-20%), however, only a small number of smallholders have potential to be profitable using commercial feed.

FIGURE 3: LARGE-SCALE SMALLHOLDER FARM WITH LARGE PRODUCTION CAPACITY TO MERIT THE USE OF COMMERCIAL INPUTS

This analysis is based on the assumption that fish are harvested with an average weight of 150g and sold at a fixed rate per kg at the farm gate. Unfortunately, in reality this is rarely the case, even successful smallholders claim that market access is a key limiting factor. Moreover, as is typically the case within this context, where mixed-sex fish in ponds begin breeding at young age, stunted growth is common and the average weight of fish is significantly reduced especially as the majority of fish farmers do not regularly remove the new fry and fingerlings, leading to marked reductions in GPM (see Appendix – Growth Profit Margin 75g average weight), therefore flagging an area for further attention for support and ongoing trainings through extension services. If calculations are revised to allow for this, then all smallholders within the sample become non-viable for commercial feed. Since feed typically accounts for between 50-80% of production cost at 150g average weight at harvest and 30-70% at 75g average weight at harvest, the ongoing financial demand for commercial feed can rarely be justified and smallholders must seek more reasonable alternatives. Discussions during this study and findings from interviews with farmers indicate that this category likely represents less than 5% of all fish farmers in Malawi.

2) Partial commercial viability but a recurring dependence on-farm inputs

These smallholder enterprises demonstrate some traits of the above, but also exhibit consistent reliance towards on-farm feeds and typically rudimentary foodstuffs with little to no modification or

enhancement. At times when commercial inputs are used, they are typically supplied by NGOs exclusively, marking a notable dependence on projects to supply and transport fingerlings and feed, as well as other farm inputs. Smallholders from this category represent approximately 15-20% of those actively engaged in fish farming, the majority of these were formed through previous donor funded initiatives rather than private sector investment. However, it could be argued that their inclusion as participants and recipients of benefit in projects could be deemed unwise, since in most instances, these farms are located in sub-optimal geographical locations that inhibit regular, affordable access to inputs and peri-urban markets. They are also likely to suffer from complications regarding consistent access to clean water and a lack of finance to procure higher value formulated feeds without credit. Furthermore, there is a distinct risk that this can result in smallholder donor dependency, whereby those receiving funds become disempowered to fulfil entrepreneurial potential. However, this is not to say that these farmers cannot achieve financial viability and notable profits through utilising quality fingerlings and local or on-farm, low-cost, supplementary feeding methods, as well as being technically competent in pond fertilisation methods; which are crucial for these lower input systems to move towards financial viability. This can be seen through the GPM, as smallholders within this category only attain positive Gross Margin with optimal average fish weights. However, as above, this assumes the smallholders have access to markets capable of paying preferred fish values at farm gate.

FIGURE 4: EXAMPLE OF SMALLHOLDER POND THAT MAY OCCASIONALLY JUSTIFY THE USE OF COMMERCIAL INPUTS

3) Non-viable / On-farm Feed and Recycling Fingerling Recruits from Previous Cycles

Smallholders within this category lack the necessary traits that would enable them to invest in commercially produced inputs without assistance or subsidy and represent as much as 80% of all fish farmers in Malawi. As above, these individuals typically become engaged in aquaculture through various NGO led projects rather than their own investment / entrepreneurship, but for a range of reasons are unlikely to sustain a profitable business. This can stem from insufficient motivation, business acumen, financial capital to invest or unsuitable location; temperature, proximity to markets and suppliers. Also, access to consistent supplies of water at the required temperature is a constraint to development of commercial smallholder aquaculture in large areas of Malawi, as discussed below. However, as aforementioned it is possible for these individuals to run sustainable, financially viable businesses if; they can maintain manage their systems effectively and secure profitable, local markets.

FIGURE 5: EXAMPLE OF SMALLHOLDER WITH POND THAT IS UNSUITABLE FOR COMMERCIAL INPUTS

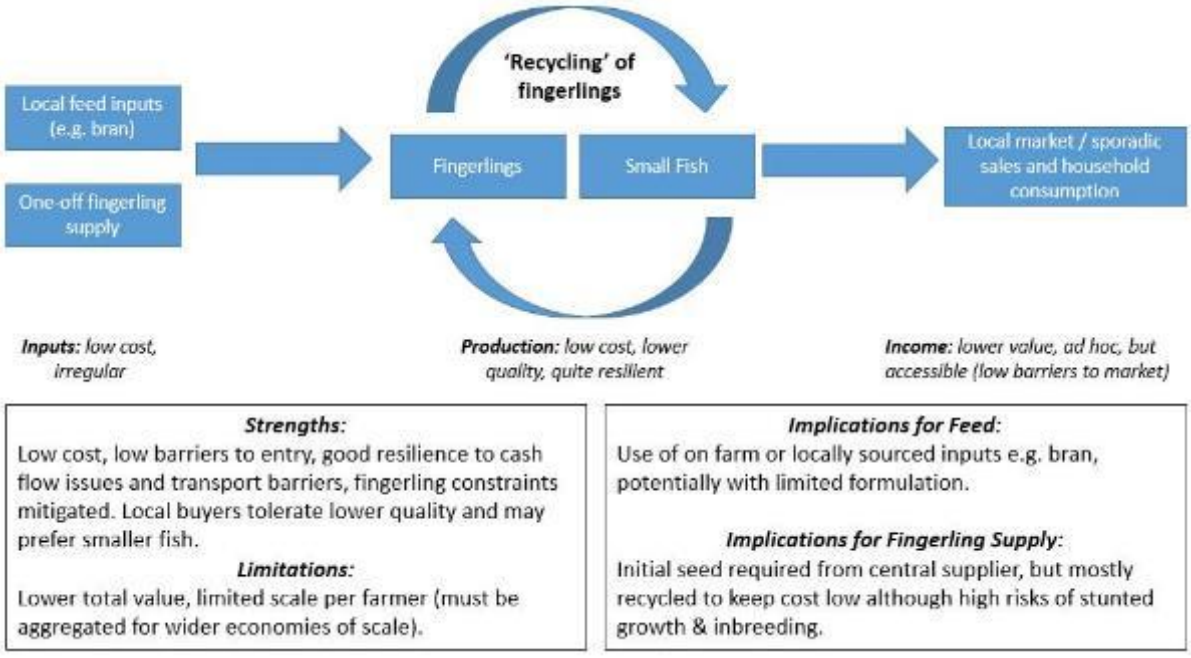


FIGURE 6: INDICATIVE PRODUCTION CYCLE FOR A SMALLHOLDER USING NON-COMMERCIAL INPUTS

Of the 9 farmers visited during this study and prior to financial analysis, four were category 1, three were category 2 and two were category 3. However, from the current sample of 9 farmers it is not possible or realistic to provide firm conclusions as to the proportions of smallholders within each category at regional or national levels. It is therefore recommended that any future study wishing to find out these figures in a scientifically based survey includes samples exceeding at least 30 farmers to attain statistically significant representative findings (preferably a sample size of 180 farmers surveyed would provide the most representative results within % statistical confidence levels).

4.1.2 FINANCIAL ANALYSIS

Gross Profit Margin (GPM) analysis was calculated for the 9 smallholder farmers that were interviewed and had received the AgriTT support (Appendix 6.5). It was much easier to develop assumptions based on the available data that farmers maintained compared to those that did not receive support from AgriTT.

The analysis revealed that the **price of inputs and selling price of fish was dependent on location and strength of other existing value chains within the community**, for example, the cost of various animal manures (e.g. chicken, goat and cattle) in Chingale, Zomba and Nkhata Bay is higher compared to the other farmers located in areas where poultry production is taking place.

Additionally, the poor harvest of maize in recent years has affected the price of maize bran which is used as a carbohydrate supplement in fish feeds by smallholder farmers.

It was further noted that those with proximity to large peri-urban markets and agricultural estates were able to sell fish at notably higher prices than the average selling value of other farmers in other rural areas, e.g. fish tilapia sold in July and August 2016 in townships near to Tea Estates in Thyolo, and the Limbe, Blantyre, Lilongwe and Mzuzu urban areas were sold at a price of up to MK 3000 / kg for fish of varying sizes (50-200g per piece at $4 /Kg).

The GPM also indicates that the profitability of smallholder farmers could increase if low cost production technologies were adopted, cycle length and ultimate fish size were reduced and lower cost alternatives to commercial feeds were available. Reducing the cost of feed to MK 20,000 / MK 400 per Kg as suggested by officials and smallholders does improve the GPM, but questions remain regarding how this reduction could be actively managed in a controlled and sustainable way. Moreover, this may compromise feed quality further, reducing the growth potential of already suboptimal quality fingerlings.

Additionally, **farmers with more ponds would likely earn higher profits** as some costs such as salaries are fixed regardless of the number of ponds one is looking after. Table 5 (Appendix) shows the GPM Analysis of the smallholder fish farmers who received support from AgriTT and participated in the study. Of the 9 smallholders included within the original sample and on the Agri TT project list, 3 were not currently engaged in any form of aquaculture activities and therefore, could not be included within the GPM. Of the 3, one individual's pond was empty and too small to produce sufficient yields to be a viable commercial enterprise; one smallholder had no knowledge of being included within the AgriTT data primary census process and had not yet engaged with any activities; the other stated he had no interest in aquaculture.

Figure 7 provides a summary of market access options for different scales of aquaculture production in Malawi. Essentially, highlighting the fact that extensive smallholder systems are usually only viable through access to local markets using local inputs, whereas larger commercial systems would not cover costs by selling at local market prices and therefore require access to larger buyers such as supermarkets. Although this is a simplified illustration, it also outlines some of the key constraints in terms of feed and seed at different scales of production.

4.1.3 GROSS MARKET ACCESS SUMMARY

FIGURE 7. SIMPLIFIED ILLUSTRATION OF MARKET ACCESS FOR FISH FARMS IN MALAWI

4.1.4 RISKS AND ASSUMPTIONS OF SMALLHOLDER PRIMARY DATA

It is important to consider the risks and assumptions that one must attribute to primary data collection with smallholder farmers.

- **Response bias -** In the majority of cases, the data retrieved must be viewed as a best case scenario based on responses rather than proven figures, attested by financial records and objective, eye-witness accounts for complete production cycles.
- **Wider context -** The calculations made in the analysis have been completed using data provided, as is appropriate. However, it is suggested that these are considered in light of well-known constraints that these farmers will face.
- **Technical limitations -** It is our understanding that many of the farmers interviewed can deliver acceptable scales of production using on-farm, formulated recipes and farm management techniques. However, due to the suboptimal quality of fingerlings, cost of external inputs and environmental constraints, it is highly unlikely that they would be able to deliver the full volumes (total Kg harvest weights) as shown.

4.1.5 GEOGRAPHICAL CHARACTERISTICS

Aquaculture is practised in all regions, however ongoing visual assessment and smallholder responses suggested that most of the Southern Region and lakeshore areas have more favourable conditions for aquaculture due to higher temperatures, in particular those areas that are closest to sea level; the Shire Basin between Chikwawa and Nsanje, as well as areas between Mangochi and Salima. The study further revealed that though the Northern region has plenty of water, the topography does not favour the construction of larger ponds compared to flatter lands in the Central and Southern regions. Furthermore, the North and Central regions are characterised by lower temperatures, which restrict fish growth throughout much of the year making it impossible to produce 2 X 6 month grow out production cycles as in the south.

4.1.6 SOURCE OF MANUFACTURED FEED

Maldeco is the only domestic supplier of commercially formulated fish feed in Malawi, based in Mangochi, in the Southern Region. The distribution hub is located 280km from Lilongwe, 200km

from Blantyre and 530km from Mzuzu. Smallholders voiced concerns regarding the poor availability of suitable formulated feed and some claimed that this lack of access acts as a disincentive to other fish farmers as low quality feed contributes to low growth of fish. As discussed previously, most smallholders using commercial feeds are doing so with some form of subsidy, rather than a direct investment of personal finances.

The alternative remains for entrepreneurial smallholders with more financial capital, who can afford commercial feeds, to form groups with other nearby farmers and purchase feeds from Zambia until such a time as the industry in Malawi has sufficient demand to stimulate further investment in large-scale feed mills and associated input costs (see section 4.2 below). Discussions with various suppliers indicated that imports are a viable option at present, however the minimum volumes are a constraining factor for the Zambian feed companies to transport into Malawi in bulk; minimum, financially viable truck load from Lusaka to either Lilongwe or Blantyre is 10 metric tonnes (MT).

Discussions with potential feed manufacturers and current livestock feed producers indicated that they are keen to scale up production of fish feed, however the volumes required to make this a viable business are currently greater than demand. It is largely for this reason that this report recommends future investment towards a short-medium term focus on fingerling production rather than commercial feed development.

4.1.7 Availability of Fingerlings

The main fingerling producing centres are in the Southern Region at NAC in Domasi and Maldeco in Mangochi. Despite there being hatchery facilities in Mzuzu, these are currently not in use due to low seasonal temperatures. Similarly, other hatcheries in the Central Region near Lilongwe including Luanar cannot supply throughout the year due to seasonal climatic fluctuations and the Government run hatchery in Kasinthula in the South is currently under construction. The study found that farmers with better access to new fingerlings each cycle suggest that they have better harvests compared with neighbouring farmers who recycle fingerling recruits from in-pond breeding; recycling of fingerlings reduces the genetic variation resulting in reduced productivity.

A key conclusion of this report is therefore that investment is required to stimulate private sector hatcheries in Malawi. While Government facilities have the technology and potential capacity to meet some smallholder requirements, they are often restrained by governmental budgetary issues whilst also over the years significantly under producing compared to their capacity and would therefore struggle to meet growing commercial demand. However, it could be argued that with the right policy support and incentives NAC and other Government centres could run fingerling production as more of a business and this cannot be overlooked as a component of future improvements, even if evidence from other countries indicates that this would be unlikely. Alternatively, the infrastructure and facilities exhibited by Government centres could be operated more effectively by developing ongoing selective breeding programmes that take on the role of maintaining good genetic lines in the form of broodstock for a range of species, to be made available to private sector stakeholders on demand. The locations of private sector hatcheries which produce and sell over 10,000 fingerlings per year and logistics issues, mean that there is a requirement for hatchery development in the Southern region in particular, to reduce losses during transport.

This conclusion does not exclude the potential for small-scale hatcheries (using hapa technology in earth ponds) and low-cost fry transfer breeding techniques to meet local smallholder requirements. There are several small-scale fingerling producers in Malawi who could be able to meet these

demands and remain a viable business if properly managed, however, a more robust, commercial system is required if the industry is to be stimulated to meet the growing demand for fish as a source of protein in Malawi.

4.1.8 *Availability of Extension Services*

The study revealed that some of the interviewees in the Northern Region ventured into fish farming after being motivated by their fellow farmers and that they rely on their friends and neighbours for extension, which sometimes is not adequate. Despite some evidence of farmer-to-farmer knowledge exchange, the lack of adequate and informed extension services and training from private sector based, experienced fish farm operators and advisors likely contributes to the low adoption rate of good farm practices amongst small-scale farmers. In contrast, most fish farmers in the Southern Region were either trained or supported by NGOs to venture into fish farming and due to location these farmers can acquire ongoing support / training about fish farming e.g. Maldeco, Domasi/NAC and Bunda.

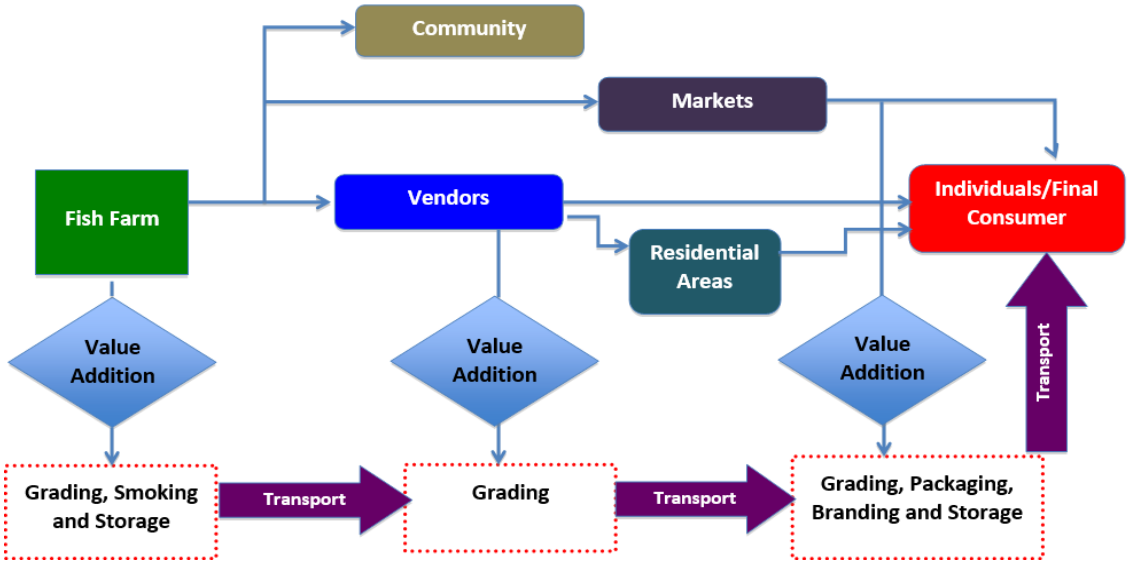
The lack of technical assistance and knowledge sharing can also be attributed to a lack of successful commercial aquaculture enterprises in Malawi that could act as motivators and hubs for development of the wider sector. This is in contrast to the success seen elsewhere in the region where countries such as Zambia, Zimbabwe and Uganda have seen steady growth in smallholder aquaculture partly as a result of growth of successful, larger, private sector farms such as; Lake Harvest (Zimbabwe), Kafue (Zambia), Source of the Nile (Uganda), since these larger farms provide the necessary infrastructure and services for smaller producers to develop (e.g. better quality and quantities of fingerlings produces and also the availability of good quality commercial feed, whether imported or domestically produced). The findings of this study confirm this, with interviews indicating that in spite of Maldeco, the lack of financially viable larger commercial aquaculture enterprises in Malawi affects the ability of the fish value chain to attract investment in the form of fingerlings and feed production, processing and private provision of extension services as in the tobacco industry. The study noted that the few, larger scale aquaculture operations that do exist in Malawi are all located in the Southern Region and as such, it is difficult for farmers in other regions to appreciate the level of investment that is required to become commercially viable.

4.1.9 *Proximity to Markets and Value-Addition*

Despite demand for fish at farm-gate and local markets, it was noted that smallholders closer to peri-urban areas and either with direct access to a vehicle or willingness to fund transport to larger markets were able to sell higher quantities of fish in less time, as would be expected. Smallholders located in remote areas struggle to penetrate these markets and suffer from reduced motivation when losses occur post-harvest. Additionally, since greater fishing activity and larger fish markets are located in the south there is a more constant demand and therefore more market potential for fish in the Southern and Central Regions. This can also be attributed to higher and increasing population density in these regions leading to an ever increasing demand for animal protein, and a large number of employed salaried people with disposable incomes, working either for the government, private sector or NGOs. However, the study team saw that fish farmers located close to large perennial water bodies such as lakes Malawi, Chilwa and Malombe suffer from competition against capture fisheries for the market. This competition often leads to farmed fish being sold at lower prices that make farming with commercial feeds financially non-viable.

Marketing is a process of raising awareness about a product's availability and stimulating demand or willingness in existing and potential customers to pay for the named product at an agreed price. It also involves comprehensive market research, informing where, when and at what price a product should be sold. It was found that the majority of smallholders lack basic marketing skills to fully utilise sales. Notable factors affecting a farmer's ability to access markets include a lack of market research, cold chain facilities, transport, poor access roads and funds to enable access. The study also revealed that the lack of reliable power and therefore reduced cold-storage options poses a considerable risk to farmers who cannot sell total biomass on harvest days resulting in significant post-harvest losses. Moreover, smallholders do very little in the way of value addition and some farmers indicated that they end up selling fish at giveaway prices or reducing value further by drying and smoking to aid preservation. In very few cases, intentional, pre-market grading and size separation occurs throughout the post-harvest value-chain, starting from the farm gate and finally at supermarkets (Figure 8).

Flow of Table Size Fish from the Farm to Final Consumer



4.1.10 *Key Smallholder Findings*

- Water issues including poor access to water / seasonality of supply and temperature / poor quality often result in farmers not being able to have more than one production cycle in a year, which has a significant impact on viability of the activity. Aquaculture can however help with **diversified income seasonally** if managed correctly with appropriate output expectations and realistic input costs.
- There are very few smallholders who have adopted fish farming as their **primary income earning activity** and are willing to invest more funds and time into growing their aquaculture enterprises as a business without external subsidy or support.
- Most smallholder farmers indicated that the **current price of feed from commercial suppliers is too high** (≈MK30,000 per 50kg bag) and would afford a price per bag in the range of MK15,000 to MK16,000. This is the price quoted for local feed formulation but would be unlikely for a commercial pellet.
- Access to **affordable feed** remains a constraint, however smallholder aquaculture can, with good associated pond fertilisation, still be a successful business up to a reasonably large

FIGURE 88: FLOW CHART DEMONSTRATING SMALLHOLDER SUPPLY VALUE-ADDITION CHAIN

scale using **locally sourced inputs rather than high cost feeds**. The alternative, which works well in some cases, is to **group farmers** together to access prices, scale and transport that would otherwise not be available.

- Hatcheries / seed remain the major constraint to development of aquaculture in Malawi as current suppliers are **unable to meet demand** with quality seed in all geographical locations. There is considerable scope for hatchery development, either through **small-scale hapa based pond operations** or a small number of commercial, more **specialised hatcheries** with tanks, incubators and specialist staff i.e. a **Thai tilapia hatchery approach**.
- The cost of fingerlings currently ranges from MK 8 up to MK 25 depending on the hatchery, size, supposed sex reversal and species requirements. However as many smallholders have not yet completed a full cycle using personal funds it is **hard to confirm how much they are actually willing to pay**. Participants included within the sample have received subsidised fingerlings from Government centres, supplemented by Maldeco when necessary.
- There is low production of fish as most farmers interviewed are unable to **consistently produce fish weighing more than 150g.**
- There is generally an **inadequate provision of skilled extension workers** who can offer on-farm experience from the private aquaculture sector, where commercial viability is essential would likely improve if there were more commercial scale operations running.
- Most smallholder farmers lack the capacity to market their fish in a commercial manner and limited **access to "out of village" markets** offer a major constraint for rural farmers.
- **Selection processes** that are used to choose smallholders for participate in projects often neglect key factors which will ultimately impact on the smallholder's **sustainable success**. Individuals who are encouraged to become fish farmers often demonstrate an **inability to maintain records**; stemming from lack the necessary **skillsets and educational background** to be able to sustain viability in a commercial setting.
- Smallholder farmers who receive training from project staff and are introduced to fish farming through project involvement **rarely receive comprehensive training that could prepare them for marketing and business management**, thus reducing sustainable outcomes.
- **Female smallholder fish farmers** demonstrate a better track record of **reliable loan repayments and sustainable financial management** of their farms (AEM experience over 3 years of loan and credit provision clearly shows that women have a much higher/ more successful payback rate on their loans).

4.2 Feed Supply Chains

The information provided is largely the result of primary data collection and observation however, this has been supplemented with experience and wider knowledge of the project team within the Malawian aquaculture sector.

The availability of quality feed is key to ensuring fish achieve optimal growth, improved FCRs and yields that achieve maximum profitability. As described previously, the majority of smallholder farmers can be categorised by their tendency to use supplementary feeding of brans, coupled with varying degrees of ability and expertise in pond fertilisation rather than invest in commercial feeds either because they do not have required funds or consider it too great a risk for spending what capital is available. Farmers may occasionally adopt pelleted feeds when funding become available

however, without suitable training in use of commercial feeds, these smallholders do not always witness improved growth rates or harvest weights and a chance to appreciate the total capacity of their ponds. At present, outside the support of donor funded projects such as AgriTT and AEM, there are limited options for the supply of commercial feed, since there is only one company producing formulated fish feeds within Malawi, Maldeco Fisheries in Mangochi. Historically, several other livestock feed companies have experimented with making formulated fish feeds, but when interviewed they indicated that it is not currently a feasible business opportunity due to a lack of large-scale / commercially viable demand. Figure 99 below shows the difference between a commercially formulated and pelleted feed, and locally sourced rice bran.

FIGURE 99. COMMERCIAL PELLETED FEED (LEFT) AND LOCALLY SOURCED RICE BRAN (RIGHT)

Government research stations are located in each of Malawi's regions. As part of this study, four centres were visited; Luanar (Bunda) University in Lilongwe (Central Region), the Department of Fisheries Office in Mzuzu (Northern region) and The National Aquaculture Centre (NAC) and Kasinthula Research Centre (Southern Region); although this final station does not supply feed. These are research centres that have a primary mandate of conducting research, both for academic purposes and on occasion in conjunction with funded projects. At present the milling facilities in these centres are used primarily for milling maize and rice for internal use. However, there are plans to build small feed mills at NAC and Luanar to produce basic formulated diets, comprising a range of ingredients sourced from within Malawi. Although these options may not exhibit the nutritional quality or digestibility of feeds offered by the more expensive formulated diets of commercial companies, the cost-profit benefit to a smallholder with limited production capacity may be enhanced. At the time of consultation, the feeds trials which were a component of the Agri TT project had not been completed, so the efficacy of this plan cannot be confirmed. If successful, it has been implied that this process could be replicated, using local ingredients and improving accessibility for smallholders in each region.

Maldeco Fisheries is the only commercial Malawian company that is producing fish feed on a large scale. The only other smaller Malawian based company that is producing feed is Chambo Fisheries in Limbe, although at present all feed produced is designated for internal use only. Two other companies are known to import feed to Malawi, however only one supports a formal arrangement and transports significant quantities. Furthermore, there are a number of feed companies throughout Malawi who produce for other livestock sectors and distribute throughout the country using a network of private and agent- run franchise outlets. It is important to consider how in the

future these stakeholders can play key roles in aquaculture development, since although it could be argued that the current aquaculture industry does not justify significant investment in feed mills, any productivity increase would encourage a healthy competition between producers in the country and thus benefit out-growers.

4.2.1 GOVERNMENT RESEARCH STATIONS

As part of this study, key informants were engaged and interviewed at NAC, Luanar University (Bunda College) and Mzuzu Fisheries Office, using a semi structured interview technique. On the 31st August, key informants including the District Fisheries Officer, were consulted at the Department of Fisheries in Mzuzu. Due to the time of year and lower water temperatures in ponds, the centre is currently running reduced milling facilities and no details regarding the milling of products for smallholders could be confirmed. Informants showed that the centre has two large mills which when operational offer basic milling facilities for local ingredients and primarily maize. Since this is a research facility, like NAC and Luanar, its primary objective is to conduct internal research and activities for funded projects. Historically, this centre has been used as a distribution centre for feed for the northern region in connection with development projects. This centre, alongside Luanar, NAC, Maldeco and Kasinthula, is currently involved in conducting tests including 3 different starter diets and 3 different grower commercial diets under the feed component of AgriTT.

On the 15th September, key informants were consulted at Luanar University (Bunda College). As part of the feed trials previously mentioned, Luanar is working with other centres to test the formulated various recipes for further assessment in a joint dissemination workshop. Further feed trials exhibiting collaboration between NAC, Luanar and Maldeco, will aim to substitute the inclusion of expensive imported fishmeal with inexpensive, locally produced protein from soya, pigeon peas and sunflower and test the digestibility and growth potential of these various recipes, although informants were unable to confirm how ingredients will be procured and whether prices will be consistent. Informants suggested that the University is due to receive a new feed mill which will be used to formulate feeds using these and other key local ingredients. This feed mill will be relatively small and a focus will be placed on feeds for internal research in the University's ponds rather than commercial purposes. For this reason, informants were not able to confirm what quantities of feed might be made available for sales to smallholders. However, it was suggested that some farmers will have an opportunity to buy this feed from Luanar at a subsidised price (≈MK13,000-16,000 per bag / 50Kg), lower than commercial rates (≈MK30,000 per 50Kg). Similar to the office in Mzuzu, Luanar has worked alongside past funded projects in the distribution of commercial feeds to smallholders in the Central region.

On the 16th September, key informants including the Head of the centre and WorldFish representative were consulted at NAC. Using the mill provided by AgriTT and following completion of feed trials and feed recipes, NAC operators plan to produce 10 T/month, with initial estimates suggesting prices of ≈15,000 MK per 50kg bag of feed. However, this is an estimated figure which is likely to change with future developments and does not account for sourcing ingredients long term. If successful, NAC will use this feed internally as well as making it available to smallholders as a low cost alternative to other commercial feeds. The aim of this scheme is to enable access for a greater number of farmers who are currently unable to purchase pelleted feeds on the basis of price alone. To date, NAC has worked closely with NGOs and donor funded projects, acting in a liaison capacity and distributing feeds. Typically, this involves NGO workers collecting feed in private vehicles for onward distribution, often to dispersed, rural smallholders that are involved within aquaculture

projects. However, at the time of this study, informants were unable to tell us how much feed they produced at this facility in the last 6 months / 2016.

4.2.2 *Maldeco Fisheries, Mangochi*

At the time of submission, the project staff were unable to gather detailed information from Maldeco and as a result the information below is based primarily on past experience and conversations as well as wider knowledge of the company history and activities over recent times. The cost of feed from Maldeco is high (MK 29,000-32,000 / 50 Kg) because the protein source, made predominantly of fish meal is imported from China and South Africa which constitutes over 70% of the total feed cost. Two sizes of feeds are available; starter and grower diets, specifically formulated to meet the needs of fish at different stages of the growth cycle. These feeds differ in pellet size, crude protein content and cost. Historically Maldeco has provided feed for internal use as well as a number of funded projects, liaising with the staff at Government institutions to distribute feeds to smallholders included within these projects. Moreover, in the past Maldeco had a number of feed distribution offices in key locations, including; Zomba and Blantyre in the Southern Region among others, from which feed could be collected, however this is now not possible and farmers must contact the offices in Mangochi directly, which poses several difficulties for many smallholders with poor connections and finance to travel.

FIGURE 10: MALDECO FISHERIES FISH FEED 50KG BAG AND FEED MILL

4.2.3 *Chambo Fisheries, Limbe*

Chambo Fisheries utilises a biofloc system (protein rich macro aggregate of organic material and micro-organims including diatoms, bacteria, algae etc). Opened in 2006, the farm aims to produce 800 metric tonnes of tilapia per annum, however this figure has never been achieved to date. On meeting with management at Chambo Fisheries on 19th September, the Farm and Technical Managers described how feed ingredients are procured from a range of sources, including fishmeal from Namibia and South Africa, however, attempts are currently being made to reduce the percentage fishmeal as a move towards sustainability. All ingredients for processing are transported by private networks. Informants claimed that the farm typically produces between 20 and 25 tonnes of formulated feed on-site per month to meet the demands of the system, however, due to the ongoing expansion of the farm and the introduction of further grow out tanks, an increase in feed production will be necessary. Management suggested that this would increase demand by approximately a further 5-10 tonnes. Initial business plans for the farm included an element of social responsibility and extension services for local smallholders, although this has yet to occur due to delays in development of the commercial operation. During discussions, management indicated that this extension service would include the provision of inputs; feed and fingerlings but it will likely be

part of a future development rather than in the near future. To date, Chambo Fisheries has not provided feed to other farmers due to internal demand.

4.2.4 *Novatek Feeds, Zambia*

A Skype discussion with key management representatives from Novatek feeds in Zambia on 19th explored opportunities for the company's involvement in Malawi. The company offer 6 specific feed types, including those for fry, juvenile and adult grow out; extruded, slow-sinking pellets comprised of predominantly soya-based ingredients and imported fish and bone meals (between 18-45% crude protein). They exhibit well established supply networks within Zambia, providing 1,500 tonnes per month to over 10 major clients (predominantly tilapia cage farms). Furthermore, as well as direct sales to individual farms, they have built relationships with over 100 independent agents and on-selling outlets, the nearest to Malawi being an agent near to Chipata, Zambia (near Malawian border) who runs a Novatek branded outlet. Additionally, Novatek currently export feeds to Botswana, Zimbabwe, Mozambique and Malawi. In Malawi, Novatek is currently known to provide 30 tonnes of feed per month to a commercial grower in Malawi for internal use only. Feed packages are transported by Novatek vehicles across the border and to the buyer in Malawi directly. However, Novatek offers fixed prices including transportation of loads between 10-15 T for packages to Lilongwe and Blantyre; starter diets of 15 Kg to starter diets of 40 Kg bag size and price increasing from ≈$14 to ≈$32 (MK 10,000-30,000) depending on location (Lilongwe or Blantyre).

4.2.5 *Proto Feeds, Kamponji Enterprises Ltd, Blantyre*

A consultation meeting with Proto Feed management staff on 19th September aimed to discuss the necessary requirements for the company's involvement in aquaculture feed production. The company CEO and Director of Operations explained that Proto Feeds major business focus is in the poultry sector. With a factory located outside Blantyre in the southern region, they provide feed to 28 feed outlets across the country by means of a comprehensive supply chain. In the past, they have displayed a desire to enter into the production of fish feeds, but did not see it as a viable business opportunity. However, within their skills base they offer extensive experience of fish feed formulation from business in South Africa, Zimbabwe and Zambia. In order for production to be commercially viable, Proto Feeds would need to have orders in the region of 100 tonnes per month. A key advantage would be that the infrastructure and equipment is already in place and in time, they have capacity to expand further to meet demands.

4.2.6 *Key Feed Producer Findings*

- Key informants within aquaculture sector, including smallholder farmers, Government researchers and NGO workers have expressed a need for **increased availability of affordable cost**, high quality feed since current prices of domestic, formulated feeds is too high for it to be **accessible** to many smallholder farmers without subsidy.
- There is currently only one commercial company making formulated feed within Malawi, Maldeco. Feeds are formulated and distributed from Mangochi.
- A number of smallholders and other farms have had experience of using **imported feeds** from Zambia and as part of AgriTT China. Informants in this study claimed that the **Chinese feed achieves good results** but that poor quality commercial feed performed little better than madeya, although they were **unable to confirm the FCRs** achieved in comparison with other feeds used.

- **Novatek** feed company in Zambia has already finalised a price per bag inclusive of transport costs to Malawi, Lilongwe, Blantyre and Mangochi, providing orders exceed 10 MT per delivery minimum (maximum 15 MT).
- If the productivity and overall production levels of the Malawian aquaculture sector were to increase, it would stimulate competition within the feed production industry, with new **Malawian feed companies, such as Proto Feeds** already showing significant interest in investment.
- **Government institutions** plan to use their own mills to formulate **low-cost, enhanced quality diets** (when compared with on-farm supplementary feeding alone), enabling more smallholders with limited resources to access. Although it must be noted that this demonstrates a replication of similar plans over recent years.
- **Lessons to be learned** from the acceleration of aquaculture expansion must draw on involvement of private sector and often, in initial stages, with the use of **imported commercial feed** to build up production to levels where local, national and international feed companies then look more favourably on opening up their own first feed mill in the country.

4.3 FINGERLING SUPPLY CHAINS

Primary data collected by AgriTT, states that the 85 grow out smallholders included had a total of 199 ponds under AgriTT (included within dataset; at times used in conjunction with trials and subsidised with inputs), totalling 111,185m^2. These ponds were stocked with 351,107 fingerlings and smallholders planned to restock 563,358 fingerlings in the coming cycle. This means that most will understock their ponds. If stocked at densities supported by AgriTT (6 fish per m^2) the total demand per cycle would increase approximately 700,000-800,000 fingerlings for the AgriTT farmers alone and on average approximately 8000 fingerlings per smallholder. Within this, the demand by farmers included within categories deemed to be viable and potentially viable for commercial inputs would exceed 400,000 fingerlings. FAO data from 2005 and recent discussions with informants provided by key informants at Government Research Centres suggest that the present total number of fish farmers in Malawi is now more than 4,500 individuals, owning over 9000 ponds.[8] Due to a lack of data regarding total pond area and stocking preferences it is not possible to predict total fingerling demand with certainty, however if these AgriTT stocking rates were used by all smallholders, demand would be >37 million per year which far exceeds current supply.

Many funded projects have sought to improve the quality of fingerling production in Malawian Aquaculture, e.g. ODA, WFC, NoRAD, leading to the government Malawi Gold Standard for hatchery development and installation of the state of the art hatchery Luanar (Bunda College), all of which failed to exhibit measurable, sustainable, long-term outcomes. Securing reliable supplies of quality, affordable fingerlings is arguably the most crucial factor in ensuring growth within the Malawian aquaculture sector. Fish growth is dependent on many environmental factors, including dissolved oxygen levels and water quality, however, genetics and related seed quality also play a key role in guaranteeing optimal growth performance and therefore the ultimate profitability of any type of livestock farm. It is important that hatcheries can supply farmers with fingerlings of uniform sizes, consistent quality and health, as well as strong growth potential from multi-generational selected breeding programmes. At present, across Malawi there are no hatcheries producing consistent batches of improved selection and/or monosex male fish, despite the partial success of previous projects at Government Centres; achieving improved strains to F_6 *Oreochromis shiranus* in 2013.[9,10] Furthermore, studies demonstrate that there was little difference in the growth and performance of this improved F_6 *shiranus* strain compared to the normal ones. This breeding programme was orchestrated by WorldFish Centre (WFC), however in recent years, the WFC discontinued its involvement with breeding programmes at NAC. This delay represents a significant hurdle for out growers since mixed-sex fish show inferior growth performance to hybrid progeny of selectively breeding programmes[11,12]. Discussions during this study indicated that there has been some research on the potential for producing monosex fish by crossing *O. karongae* and *O. shiranus*, but at the time of writing there is not firm evidence of this happening at a commercial level.

[8] http://www.iceida.is/media/pdf/Malawi_Poster_Namibia_Workshop.pdf.

[9] FAO (2015) Applied research, education and training - National Aquaculture Sector Overview, Malawi. [Accessed 18th September 2016 at http://www.fao.org/fishery/countrysector/naso_malawi/en].

[10] Progress Report of the Selective Breeding Program in Malawi. [Accessed 18th September 2016 at http://pubs.iclarm.net/resource_centre/Partner-Annual-Report-2013-Malawi.pdf].

[11] Gjedrem, T. *et al* (2012) The importance of selective breeding in aquaculture to meet future demands for animal protein: A review. *Aquaculture* (350–353) 117–129.

[12] Eknath, *A.E. et al* (1998) Selective Breeding of Nile Tilapia for Asia. 6th World Congress of Genetics, Australia. 1-9.

There are a range of hatcheries/fingerling producers currently producing fingerlings for on-sale to smallholder fish farmers; using predominantly breeding in earthen ponds rather than hapa or incubator based hatchery systems. As a consequence of this more extensive pond based production of fingerlings, the resultant fry and fingerlings are normally of a much lower quality than those produced where known numbers and ratios of broodstock are stocked into hapa based systems; where fry are collected on a regular 5-day cycle. Very few hatcheries in Malawi have access to the more capital intensive 'incubator and tray systems' which are used widely across Southern Asia and Latin America to produce millions of sex-reversed tilapia fry each month.

Broadly speaking, producers can be split into two groups; Government Research Stations and Private, Commercial Hatcheries. The commercial operations are owned either by large companies or by smaller scale commercial farmers, the latter resulting to an extent from various Government and NGO led projects seeking to boost production in smallholder clusters, creating service linkages between farmers, the most recent of which being AgriTT. Although this concept can work well a key constraint is the sustained motivation of hatchery owners post-project when demands from smallholders can fluctuate, project subsidies cease and operating costs become harder to manage. Further complications can arise in specific locations where annual fluctuations in climatic conditions do not promote for favourable breeding conditions. This can be seen most prevalently at higher altitudes, where for several month of the year water temperatures fall well below 20˚C. These temperatures are not conducive with stable reproduction of indigenous tilapia species.

Government Research Stations are typically equipped with large, professionally designed and engineered pond systems and on-land hatchery facilities. These centres are the stage for a range of both historical and ongoing projects incorporating species specific growth trials for a range of different species including; tilapias, catfish and carp species. However, it was noted during review assignment that it was often very difficult to access and read results and publications from these trials, whilst also not possible to obtain a summary of the results from the associated staff working on these Research Stations. These stations are responsible for providing fingerlings and to demonstrate a mandate to provide extension services to smallholders. These activities typically include farm visits involving training smallholders regarding fingerling stocking, pond management and fish husbandry. There are several private, commercial producers of fingerlings within Malawi, varying in terms of capacity, geographical location and reliability. These are all geographically dispersed and in the case of some of the smaller producers, they can be very remote.

4.3.1 GOVERNMENT RESEARCH STATIONS

Following discussions relating to feed, key informants in each of the Government stations were asked questions relating to fingerling production as per the topic guides. Meetings with the Centre Head and the WorldFish representative at NAC outlined that the centre's main mandate has been to conduct research focussing on genetics, feed and developing country specific production technologies. In the past, WorldFish implemented a project that aimed to build capacity of NAC and Luanar (Bunda College) towards managing and improving broodstock whilst simultaneously setting up several satellite hatcheries to extend outputs to a wider geographical area, although these hatcheries experienced immediate production difficulties and to date production cycles have struggled to prove financial viability (see AgriTT primary dataset). The project also helped to set up nursing hatcheries where farmers were trained on how to nurse fry (using Asian tilapia methodology of growing fry from <1g to 5-10g in green water, earth pond systems for 3-4 weeks). This project helped to reduce the cost of fingerlings to MWK5 each. Unfortunately, these satellite beneficiaries

have struggled to maintain commercial productivity and the selective breeding programmes are now limited.

NAC has capacity to produce ≈5 million fingerlings per year at its hatchery site in Domasi. However, since the research facility is not operated as a commercial business and has other core areas of focus, this capacity has not been reached to-date. The centre is currently capable of producing between 200,000-300,000 per month depending on the season and demand, and they have supplied to both commercial growers and smallholders in the past, although the majority of production is for the latter, including; ≈1.8 million for AgriTT, District Assemblies and ASWAP. Fingerlings are now produced at around MK15-20 per piece. Even this relatively low price is largely out of the affordable range of most local smallholders. Management informants from NAC and WorldFish stated that there are circa 1,000 fish farmers who have bought fish from NAC, either as individuals or as part of projects, although it cannot be confirmed that all of these farmers exhibit the necessary business acumen to ensure viability.

The Aquaculture Department at Luanar University (Bunda College) near Lilongwe has received support from Chinese AgriTT technicians towards improving its capacity in fingerling production. As mentioned previously, this process was matched with simultaneous support to more established, satellite farmers through improving the infrastructure of their fish farms. Prior to AgriTT involvement Luanar's capacity to produce fingerlings was around 1 million per year. Information available indicates that the capacity has now been enhanced such that Luanar can produce close to 2 million fingerlings per year, although, it was not possible to substantiate the figures provided. The fingerlings produced are sold mainly within the central region and predominantly to NGO's who then distribute to smallholders as required. In this system, NGO's are responsible for organising all aspects of the supply chain, from payment to collection and transportation on behalf of farmers, which on behalf of this report we would question in terms of standalone sustainability of these smallholder fish farmers to survive and do it themselves. Luanar's price for fingerlings is currently MK20 per piece (Sept 2016). The key informant at Luanar said they had future plans for the production of monosex fingerlings, primarily *O. shiranus*. In addition, catfish, *C. gariepinus* has been highlighted as having strong potential for production at the research station due to its favourable growth rate and ability to adapt to poor water quality. He added that engagement with the AgriTT project has enabled the introduction of new technologies and methods to reduce mortality rates of catfish fry.

At the time of visit on 31st August, the hatchery unit at Mzuzu Department of Fisheries in the north of Malawi was inactive due to low water temperatures. Informants were undecided as to when production would start as this depends largely on water temperatures being high enough to encourage breeding. However, fingerlings procured from another facility have been stocked to enable feed trials to occur, despite lower water temperatures. The Centre comprises 4 large ponds as well as an indoor hatchery unit. Like other hatcheries, the indoor facility has been developed to cater for the production of catfish although water temperatures being too low for breeding most of the year. Informants stated that production depends largely on demand and no accurate figures could be presented for previous production cycles over recent years.

The Kasinthula Research Centre is located south of Chikwawa town and supports over 10ha of earthen ponds this government research station which formerly was a commercial fish farm, leased out to a private sector Asian business man, has capacity to produce a significant tonnage of tilapia,

catfish and carp. The climatic conditions in the Lower Shire mean that this centre offers possibly the best growing conditions for indigenous species and therefore has significant potential as a commercial hatchery location. Furthermore, with its location 1km off the M1 (north to Blantyre and south to Nsanje), this centre is perfectly situated to act as a provider for the Lower Shire Basin. Currently, the centre is undergoing a transition period with new management, pond clearing and the

building of a new hatchery unit. The Informant stated that technical extension is provided to over 200 smallholder

FIGURE 11: INDOOR HATCHERY FACILITY AT MZUZU DEPARTMENT OF FISHERIES OFFICE AND HAPAS IN POND FOR FINGERLINGS GROWTH / FEED TRIALS

farmers in the region; Lower Shire Basin. Current capacity for fingerling production is unconfirmed and it can be expected that only small amounts will be available in the coming year due to redevelopment in 2016. Full capacity at time of commissioning could exceed 100,000 fingerlings / month based on discussions during this study, however again actual production and sales of fingerlings can be confirmed when the site is up and running.

4.3.2 SMALLHOLDER FARMERS

As aforementioned, a historical WorldFish Centre project that involved the facilities and staff at NAC and Luanar, provided a Technical Assistant in broodstock management, with the aim of initiating a selective breeding programme so that it could serve a satellite hatchery owned by Mr. Penemulungu in the Central Region, close to Lilongwe, to utilise the enhanced genetics of the parent stock from NAC and Luanar. Mr. Penemulungu was consulted on-farm as a key informant on 16th September to discuss current levels of productivity at his hatchery. It was stated that due to factors including;

location, scale and technical ability, this private hatchery is well situated to act as a fingerling supplier for farmers along the M1 road network. This informant described how although out-growing is an element of the enterprise, fingerling production is the core business focus for his farm. Due to the time of year, water temperatures and availability, no fingerlings were being produced for commercial purposes. However, he stated that in the past, he was able to produce and sell approximately 3million fingerlings to NAC (National Aquaculture Centre). His fingerling production service also includes packaging materials for transporting fingerlings; plastic bags are sold at MK200 while oxygen is sold at KM60 per bag and fingerlings are sold for MK25 per piece to farmers. In the past the farm has provided tilapia fingerlings for 20 fish farmers from; Lilongwe, Salima, Mchinji and Nkhotakota. As well as supporting several large ponds for breeding, the farm includes an indoor hatchery facility with separate sections for catfish and tilapia. This in-door hatchery is currently under construction and he could provide no fixed figures regarding production capacity, although it was suggested that the hatchery could produce over 1 million fingerlings per year if there was enough demand. To assist in the breeding of catfish, the business received 1,500 females and 1300 male catfish fingerlings from NAC. His plans for the immediate future include an increase in the production of catfish, involving the collection of wild-caught fingerlings from Chikwawa and Nsanje. However, despite the favourable location and infrastructure, the individual voiced concerns regarding water temperatures and water availability throughout the year, since the regular electricity shortages constrained pumping and water heating facilities. Furthermore, it was observed that significant investment has been made in in the construction of a catfish hatchery, despite insufficient water temperatures and a lack of demand by grow out smallholders.

FIGURE 12: BREEDING PONDS AT SATELLITE HATCHERY NEAR TO LILONGWE

4.3.3 MALDECO FISHERIES, MANGOCHI

As above, at the time of submission, the project staff were unable to gather detailed information from Maldeco and as a results the below is based primarily on past experience and conversations as well as wider knowledge of the company history and activities over recent times. The largest commercial fish farming company in Malawi, Maldeco Fisheries, a subsidiary of Press Corps, has been the site of much investment and project focus over the last 10-15 years. The farm exhibits a combination of large, inland, earth ponds as well as cages on the lake. Following the installation of a large, sophisticated hatchery unit. Maldeco has capacity to produce 600,000 to 800,000 fingerlings per month and informants stated that the farm produced approximately 1 million fingerlings in the last year specifically for on sale to Research Institutions and funded projects to contribute to provision smallholders.

FIGURE 13: HAPAS TO HOLD FINGERLINGS AT MALDECO HATCHERY FACILITY.

4.3.4 *CHAMBO FISHERIES, LIMBE*

During a consultation meeting on the 19th September, Management staff at Chambo Fisheries demonstrated how the farm supports a complete, vertically integrated production system for growing tilapia; *O. shiranus* and *T. mossambicus*. An indoor hatchery system is used to produce two batches of fingerlings per month. This system includes 10 separate jars for egg incubation, each with a capacity to hold 60,000 eggs (total 600,000 eggs), however at present the farm only uses as many incubators as are needed to meet internal demand (approximately 200,000 per month). With various tanks currently under maintenance and refurbishment, the farm aims to stock further tanks in the near future. This will lead to the hatchery being used to full capacity. The farm's original intention was to fulfil a mandate of social responsibility, alongside private production, including production and sale of fingerlings for local smallholders. Due to changing priorities and production requirements, the farm has instead had to focus more on developing the systems for grow out rather than external supply of fingerlings.

4.3.5 *CHIPOKA FISH FARM, CHIPOKA*

Located south of Chipoka on the lakeshore, this farm offers 6 large earthen ponds of varying sizes and cages on the lake (4 cages at 2km distance, 4 cages at 8km distance and more currently under construction) for growth of multiple tilapia species and catfish (*C. gariepinus*). According to the owner when interviewed, this farm has the potential to produce a significant tonnage of chambo and catfish. The farm supports an indoor hatchery and breeding ponds. Fingerlings for internal use are stocked in ponds and then transferred to cages for final grow-out for a period of 6 months. Currently the hatchery has capacity to produce 120,000 fingerlings per month, however, there is an internal demand for ≈20,000 fingerlings per grow out cage that must be satisfied before external sales can be made. The hatchery has recently provided approximately 20,000 fingerlings to another fish farm in Chikwawa. During the consultation, the informant indicated a specific desire to develop provision of fingerlings to out growers in order to boost productivity within the wider sector.

4.3.6 *CHONONA HATCHERY, MASEYA, CHIKWAWA*

Located in Chikwawa this hatchery and grow-out farm has set up from a greenfield site in the last year, 2015, which focusses on the production of both tilapia and catfish; *O. shiranus, T. rendalli, and C. gariepinus.* In its first 12 months the farm has already begun to sell and distribute tilapia fingerlings to smallholder farmers who were previously included within the Aquaculture Enterprise Malawi (AEM) project, however the intention according to one of the two owners is to move towards a full, commercial strategy. Due to the farm's location, water temperatures remain stable above 25˚C for over 8 months of the year, peaking above 30˚C and rarely dropping below 20˚C. Due to the farms young age it is difficult to confirm their maximum capacity for fingerling output; current estimates suggest production of between 5,000-10,000 fingerlings per month during season is certainly achievable, which would go a long way towards meeting demand in the region for smallholders in particular. Current work is underway to explore the potential links that can be built between this hatchery and other surrounding fish farms in the Chikwawa to Nsanje area.

FIGURE 14: BREEDING AND GROW OUT HAPAS FOR FINGERLINGS AT CHONONA FARM, CHIKWAWA.

4.3.7 KEY FINGERLING PRODUCER OBSERVATIONS

- All fingerling producers expressed a **capacity to increase** supply if demand increases.
- The majority of tilapia fingerling producers across southern and central Malawi are **using extensive, unscreened inlets** earth pond systems where they stock in originally known numbers of broodfish and then allow them to **breed naturally** and then periodically remove the resultant fry.
- There are very few fingerling producers who use **hapa based production** and even fewer who use **Thai style commercial hatchery incubators and trays.**
- The result /outcome of the above two points is that the quality of the majority of the fingerlings sold is of low/mixed quality.
- Informants suggested that the majority of fingerlings produced are sold or provided for smallholders at **subsidised costs**, in connection with funded projects.
- There are less than 5 large hatchery facilities with systems capable of producing **50,000 fingerlings per month or more**.
- Hatchery producers are geographically **dispersed** making it challenging for smallholders to access fingerlings without support to assist with communication, transportation and liaison.
- Smallholders can **rarely afford transportation** to collect fingerlings without funding, credit provision or supervision. Smallholders should be **grouped** to enable neighbours easier access to the nearest / most suitable hatcheries. It is important to note that logistical issues are not limited to vehicle access, but transport is impacted by factors such as temperature, water

quality and oxygenation equipment, so all of these should be considered when reviewing access to fingerlings for farmers. The locations of some hatcheries supported by government and also donor funded projects e.g. Mzuzu and Lilongwe are not suitable for fish breeding for significant periods of the year due to **low water temperatures**.

- Hatcheries near to the lake and Chikwawa expressed fewer concerns over water temperature throughout the year.
- Despite WFC's previous investment and research in the past there are currently no **large-scale selective breeding** programmes working towards commercial outcomes.
- Hatcheries struggle to produce **consistent monosex fingerlings** which reduces performance in grow out. In the past, many of the informants have attempted to produce monosex but with **little consistent success**. It is still not clear to many existing or potential new hatchery producers how and where they can access the necessary **17 Methyl Testosterone hormone** in order to carry this out.
- Further research and on-farm experimentation are required to confirm the true benefit of **mixed-species hybridisation**. AgriTT trials including *O. shiranus* and *O. karongae* have explored this as an alternative to hormone induced sex reversal.
- The **price of fingerlings fluctuates** significantly between hatcheries and over time. There is some evidence to show that fixing of fingerling prices is occurring through a range of government, NGO and also private sector organisations. Which indicates that aquaculture development in the country is **not yet mature** enough to improve free market supply and demand to set price.
- However, in terms of the total production costs of typical Malawian smallholders, earth pond tilapia grow-out producers fingerling **costs are still a relatively low %** of their overall costs ~12 -15% with commercial feeds (if they are being used) being far more significant at around 65-70% of total costs.

4.4 Distribution of Stakeholders

As shown in Figure 15 below, most hatcheries are located in the Southern region and the two main suppliers in the Central and Northern regions are Government Hatcheries (as shown by blue markers). As mentioned previously, fingerlings are often distributed to smallholders by NGOs and those engaged with donor funded projects, who are able to travel long distances in private 4x4 vehicles, unlike smallholders themselves who largely use public transportation. This has enabled hatcheries to distribute fingerlings to a greater range of smallholders in distant locations.

This is also the case for current suppliers of commercial feed, since Maldeco is located in Mangochi, Southern region (as shown by yellow markers) and Zambian feed companies operating through transport to Lilongwe and Blantyre only. Furthermore, the distribution of this feed has largely involved the facilitation of project operators rather than smallholders specifically. Feed is also produced in Government research stations, however as mentioned previously, this is limited to basic milling facilities and the proposed plans for the simple recipes, involving formulating low-cost locally sourced ingredients.

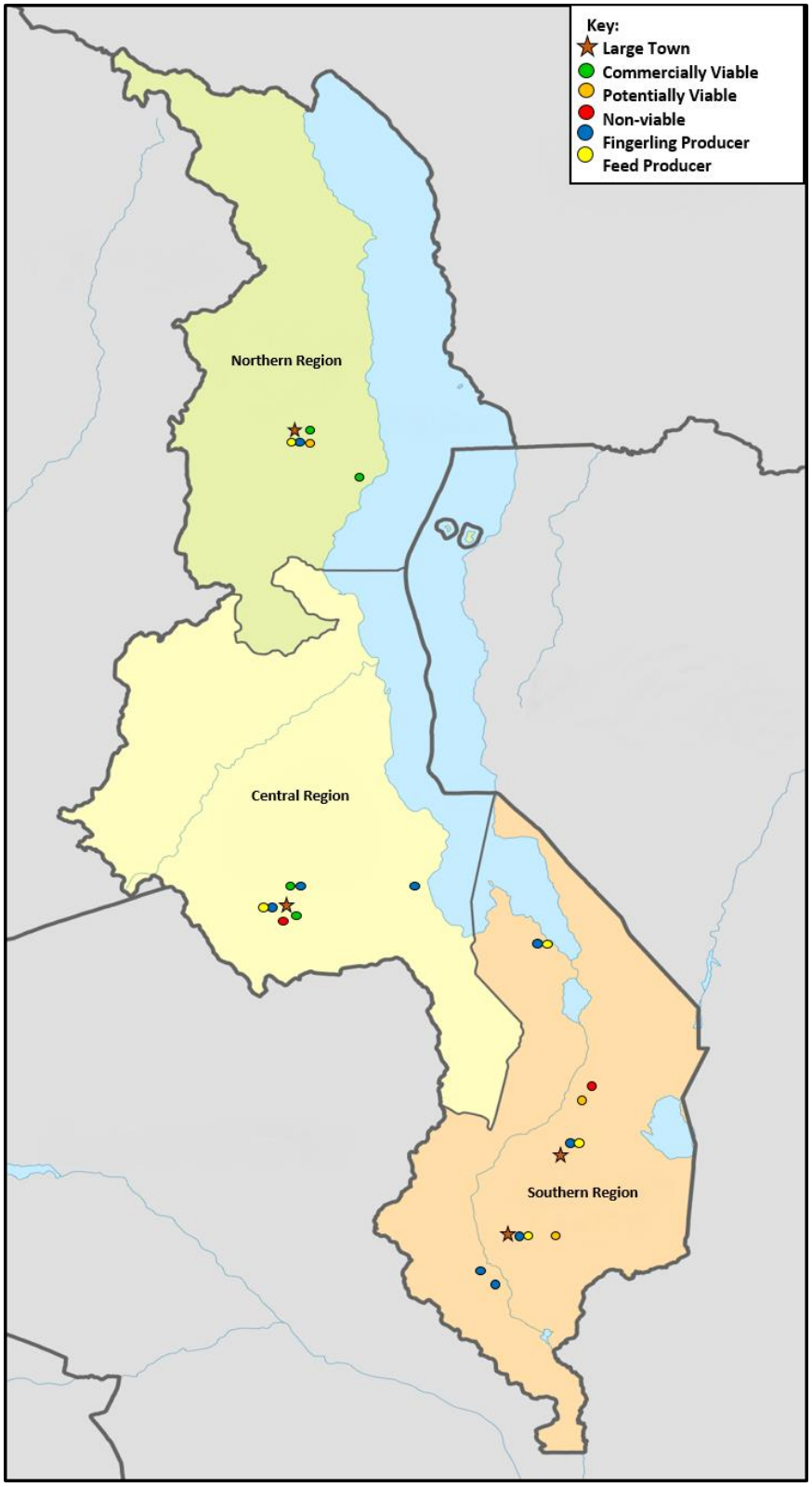


FIGURE 15: MAP SHOWING DISTRIBUTION OF SMALLHOLDER FARMERS WITHIN STUDY SAMPLE (CATEGORY 1 GREEN, 2 ORANGE AND 3 RED), AS WELL AS THE LOCATIONS OF STAKEHOLDERS WITHIN SUPPLY CHAINS FOR FINGERLINGS (BLUE) AND FEED (YELLOW) (ADAPTED FROM: WIKIMEDIA 2015)

5. Discussion & Conclusion

This study has set out to identify the potential mechanisms and organisations / institutions in Malawi, through which the commercialisation of smallholder aquaculture can be greater realised. The commercialisation that is needed in Malawi could take the form of encouraging and supporting the development of new farms or expanding existing facilities, or it could also focus on strengthening of the current supply chains to improve stability and sustainability of the sector by becoming more market focussed.

There are a number of options available through which improvements and increased scale could produce the end result of improving the commercial viability of smallholders, while also benefitting the wider aquaculture sector across Malawi. As the study has focused on feed and seed specifically, these are discussed briefly below with reference to specific organisations as required, prior to conclusions being drawn. It is also important to note here the time and scale limitations of the report. Many contributors gave their time and input generously to the project, however it was not possible to speak to all those involved in the sector.

5.1 Feed

The commercialisation of fish feeds in Malawi can be achieved through a number of interventions identified below.

1) Large-scale commercial feeds

Currently in Malawi, farmers who want and have the necessary funds to buy commercial feeds already have the option of purchasing from Maldeco in country, or importing from companies such as Novatek in Zambia and South Africa. With potential for further growth within this sector in Malawi and the ever-growing demand for fish, the need for commercial feed is only going to increase in future, and the option therefore remains to consider investment in new large-scale milling facilities, or capacity building within value chains for existing operations. Discussions were also held with other potential suppliers within the poultry sector, who could relatively easily transfer skills and equipment to fish feed production. However, it is unlikely that growth of large-scale feed mills will be advisable in the short-medium term until demand is considerably higher than the present time. *The capacity to supply commercial feed in Malawi is promising in proportion to the growth of the industry.*

2) Small-scale feeds using local ingredients

Interviews with the Government Research Stations and some small private sector growers highlighted that there are a number of small-scale feed mills throughout the country, although very few, if any, are producing commercial feed for sale at the current time. The AgriTT project is supporting on-going feed trials at the time of writing and it is hoped that a key outcome of these will be innovative local feeds which will be a viable option for the majority of smallholder farmers included within the AgriTT project. There is a positive evidence base from countries like Kenya and Uganda where larger scale international donors like USAID who have in the last ten years constructively supported smaller-scale, regional feed producers to set up standalone businesses to produce a lower cost affordable feed which local small scale fish farmers can afford and also perform well in well fertilised pond systems.

This sort of successful collaboration was not so much based on the subsidized purchase of the equipment, e.g. extruder but rather, more importantly the mentoring and technical support provided in country from specialised commercial fish feed business practitioners from the United States. In terms of commercialisation of the Malawian sector, it is likely the growth of these smaller producers that will be of greatest benefit to smallholders as in Kenya and Uganda in the short-medium term in relation to their feed requirements. *This segment has some capacity on which to build and can reach local fish farmers.*

3) On farm feeds using local inputs

The use of on farm or locally sourced ingredients for feed is well-documented and has been practiced in Malawi for many years. Although this level of extensive farming is unlikely to be a viable stand-alone commercial business for smallholder farmers, it can still cover its own costs and is likely that these farmers will continue to play a crucial role in the shape of the Malawian sector for a long time to come. *This is still a rational commercial segment to support.*

5.2 FINGERLINGS

As with feed above, there are a number of mechanisms through which seed could be commercialised in Malawi for the benefit of smallholders:

1) Large commercial hatchery

At present, fingerlings can be purchased on a large scale in principle from a number of sources in Malawi, including the Government Research Stations and Maldeco. There are however, a range of constraints to this including; the fact that the research stations are already committed to supplying their own research requirements, supply to smallholders through NGO projects and a lack of business focus. There is also a seasonality of supply available from these stations due to water supply and temperatures, which is a constraint to developing a commercial sector in Malawi. As a result, there appears to be scope for investment in at least one mid to larger-scale commercial hatchery in Malawi or capacity building existing facilities to help meet the growing demand for seed. Moreover, the public sector and Government facilities should implement quantifiable and achievable business plans if they are to be involved in input generation and distribution (depending on geographical location and scope of funding). As demonstrated in the context of other surrounding African countries, public sector facilities can, if supported by funding from donor projects, play a crucial role in ongoing research and selective breeding programmes. This will in turn, assure private sector operators of consistent supplies of broodstock when required. *Large commercial hatchery supply is still a significant barrier to growth.*

2) Small-scale / smallholder hatchery

Small scale, earth pond based hatcheries play an important role in smallholder aquaculture, particularly in the Southern region where they provide the only realistic option for farmers to access seed, irrespective of quality and overall fingerling health. There is significant potential for growth of aquaculture in the Southern region where the climatic conditions are favourable and water is generally available year-round. As a result, it is likely that supporting the growth of carefully selected small scale hatcheries, with commercial viability and nearby networks of other farmers, would have considerable benefit to the commercialisation of Malawian smallholder aquaculture. Further support should include collaboration between Government extension officers and such

hatcheries, providing assistance to identify clusters of farmers who could collectively finance the transport of fingerlings on demand. *Small hatcheries can mitigate supply risk and expand the hatchery knowledge and supply base.*

3) Use of recruits internally

The recycling of seed in ponds continues to be important for many subsistence-level fish farms with extensive systems, particularly those who are in remote areas and do not have the infrastructure or funds to transport and restock new fingerlings regularly. Although this type of farming will not generate large income for farmers and is unlikely to see individuals increase in scale, it can still be considered commercial as it can cover its cost with minimal inputs and still results in fish being produced for subsistence and occasional on-sale at farm-gate or nearby markets. *Initial supply can allow a resilient model of recycling seed, mitigating risk and keeping low-cost, low-value production sustainable.*

5.3 CONCLUSIONS

Having undertaken extensive consultations for this study and reviewed the current status of the aquaculture sector in Malawi, the main conclusion drawn here is that the priority for commercialisation of smallholders should be the development of more reliable, year-round supply of fingerlings – ideally monosex. Although this may not be the traditional mechanism in Malawi, evidence from elsewhere in Africa and internationally indicates that this is a key stimulus to driving growth of the aquaculture sector and will be crucial for Malawi going forward.

The development of commercial feed will inevitably be important for the sector once it reaches a size that justifies the investment that would be required, however the sector simply is not yet big enough to create enough demand. Interviews with companies such as Proto Feeds and Novatek suggest that there is an aquaculture industry waiting to emerge in Malawi, and it will certainly grow when the demand is there. In the meantime, it is suggested that commercial smallholders either continue to use the feed available in Malawi via Maldeco post project support, or consider working together to achieve the numbers required to import high-quality feeds in affordable volumes from elsewhere in the region. The current feed trials being run through AgriTT will also play an important role going forward as they could hopefully provide a mechanism through which small scale feed mills become commercially viable using local ingredients, and therefore produce a good quality feed that is used by Malawian smallholders.

It is unlikely that many smallholder farmers will use a commercially formulated pelleted feed unless there is a reliable, locally accessible and affordable credit/loan provider as in the AEM model. The costs are always likely to outweigh the profits to be made in extensive, or even semi-intensive systems, which is the case for the significant majority of all fish farmers in Malawi at present.

The importance of small-scale cage culture will likely grow in the coming years in Malawi as interest surrounds their further use. This would also support the growth of the feed sector, and vice versa. To date, there have been very few examples of cages being used successfully, however, this is an area for further investigation and grow out trials since there remains no fundamental reason why this form of aquaculture would not be viable in Malawi. Smallholder cage projects in East Africa and Zambia have shown how this can work well and growing this skill / resource base in Malawi could have considerable benefit on the aquaculture sector – further details can be seen at www.bomosa.org and www.yalelo.com/yalelo-out-grower-scheme-launched/.

The information provided through AgriTT and consultees in this study indicates that even at present production volumes, there simply isn't enough seed and of the necessary quality available to meet the demand from smallholders let alone the growth of the larger commercial sector**.** Prior to investing in hatchery facilities or specific locations, it would of course be necessary to undertake detailed assessment of likely demand in specific geographical regions for development to ensure uptake is focussed and successful, but indications from this study and team experience suggest that there is demand. Until such a time that there is a reliable, year-round supply of fingerlings available, the industry will continue to struggle to develop commercially. It is important to note that other constraints have been identified and discussed briefly in this study e.g. extension support / training, transport / infrastructure, however they have not been discussed in detail as are out with the specific requirements of the report. Any future intervention and investment in the sector will always need to consider the wider constraints and ensure a balanced approach to addressing each of these, rather than identifying a single barrier to tackle.

Nearby countries such as Zambia, Kenya and Uganda provide examples of how the development of the private sector can play a critical role in how the aquaculture sector grows around a commercial hub. Private sector growth can either be allowed to occur naturally, or with motivation from Government and international donors to attract private sector engagement. In Egypt, this hurdle was approached by a proactive and forward looking government strategy designating suitable land to the use solely for aquaculture production, providing the necessary infrastructure i.e. water supply canals, feeder roads and access to nearby lucrative peri-urban markets and then simply inviting private investment to take ownership. In Zambia, smallholder producers have benefited from the expansion of large, commercial entities who brought forward the development of good quality feed and fingerlings for themselves first and then the smallholder sector benefitted in their wake. Smallholders can receive considerable benefit in terms of access to inputs that come from larger-scale commercial aquaculture, and so it is essential that this area receives continued support to grow moving forward in order to ultimately benefit smallholders through the cascading effect of a thriving sector.

Small scale hatcheries and feed mills will continue to play a key role in Malawian aquaculture, especially for smallholder farmers working with small scale, extensive systems for subsistence and local sales. However, the sector as a whole is in need of more productive, large-scale hatcheries to drive the growth that is required. This will almost certainly occur with the simultaneous growth of one of more large, privately owned farms. With the population growing at current rates, the demand is only going to increase and with it the need for more commercial fish farms.

6. APPENDIX

6.1 TOPIC GUIDE - SMALLHOLDER FARMERS

Introduction

- Introduce self and project / Explain purpose of the project and re-visit AgriTT
- Confidentiality and how findings will be reported

Background of Interviewee

- Name and contact for interviewee – farm owner (as named in AgriTT dataset)
- History of land use and employment (alternative livelihoods / ownership)
- History of aquaculture involvement and personal goals
- Existing productivity (pre-AgriTT) and Impact of AgriTT activities on production
- Current constraints to improved productivity and profitability
- Investment in Aquaculture? How much time do you spend on farm compared with other work?
    - How much income compared to other work (per year / month / 6 month)

Sources of Feed and Fingerlings

- Current source of Feed, how this has changed and how is it accessed (how far / how often?)?
    - How much do you spend on feed? Daily, weekly, monthly, cycle, annual?
- What are your main concerns / if any, regarding feed provision?
    - Price, quality, FCR achieved, On-farm or formulated feed (cost-benefit), affordability, experience of growth rates, cycle length comparisons, interest imported?
- Current source of Fingerlings / has this changed? How and how often do you purchase?
    - Where? How much do you spend on fingerlings and how often? Has this changed?
- Do you trust producers / supplies for fingerlings and why? What is your past experience?
- Main concerns / if any, regarding fingerling provision?
    - Disease, size and species, transport issues, correct numbers, price, mortalities in early stage, seasonality of supply, communication with suppliers?
- Innovative activities on farm (on-farm feed, breeding programmes etc).

Connectivity and Market Segmentation (Flow diagram output)

- How, where and how often do you sell fish?
    - # total harvests in last year? Total Kg Harvested, how much sold / kept?
- How does a harvest day work? Does somebody sell for you? Is there grouping for sales?
- How do you investigate current prices for farmed fish? Do you do research?
    - Farmgate, Local village, near town, large markets (district and regional large towns)
- Do you keep records of sales and harvesting for comparisons?
- Do you connect with other farmers or other businesses for sales? FFs Assoc or grouping?
- What are other local fish farmers doing? Production, differences in approach, Information sharing or are they separate? How long have they been there?
- What are some of the innovative ways and products of marketing fish?
- What are the main challenges you face in marketing fish?
- Do you get support from Extension Officers, DFO, Donors? What support? Do they visit?
    - Have you been involved in other projects in the past? Received in funding, who from?

6.2 Topic Guide - Feed Producer / Supplier

Feasibility Study into the Commercialisation of the Feed and Fingerling Supply Chains for Smallholder Aquaculture in Malawi. Aiming to identify gaps in existing knowledge through semi-structured interviews with stakeholders in supply chains of inputs, to understand how; their businesses can support smallholders with suitable production capacity to justify their involvement.

Introduction

- Introduce self and project / Explain purpose of the project and re-visit AgriTT
- Confidentiality and how findings will be reported - Any questions?

Background of Interviewee

- Name and contact details of interviewee
- History of work within production and supply
- Existing productivity in other forms (agriculture / agri-business?)
- Existing networks in Malawi – number of clients, challenges, areas for growth?

Sources of Feed

- What feed do you currently produce? Different types, ingredients and nutritional content?
- How and where do you currently make your feed? Scale of production and cost?
    - Where do you source ingredients? How and consistency?
- How many businesses / indiv. farmers do you currently serve? How many could you serve?
    - What would need to happen for you produce more / for more people?
- How do you make feed available? How could this be improved for aquaculture specifically?
- Do you have gaps in the quality of feed produced and how could they be addressed?

Connectivity and Marketing

- How do you currently market your products / where are they sold?
    - Do you sell through other businesses and shop chains? An area for expansion?
    - How much did you sell in the last year for different types of feed?
    - How much did you sell for aquaculture specifically (if any)?
- What in your opinion are the future prospects? Give reasons for your answer?
    - What would need to happen for this to change?
    - Is there anything inhibiting growth of your business or others?

The future, Increasing Scope and Awareness

- Suggestions for improvements of feed production and marketing within aquaculture specific sector?

6.3 Topic Guide - Fingerling Producer / Supplier

Feasibility Study into the Commercialisation of the Feed and Fingerling Supply Chains for Smallholder Aquaculture in Malawi. Aiming to identify gaps in existing knowledge through semi-structured interviews with stakeholders in supply chains of inputs, to understand how; their businesses can support smallholders with suitable production capacity to justify their involvement.

Introduction

- Introduce self and project
- Explain purpose of the project and re-visit AgriTT
- Confidentiality and how findings will be reported - Any questions?

Background of Interviewee

- Name and contact details of interviewee
- History of work within production and supply of fingerlings
    - How did you start your business? How has this changed?
- Existing productivity in other forms (agriculture / agri-business?)
    - How much time do you spend producing fingerlings / percentage involvement?
- Existing networks in Malawi – number of clients, challenges, positives?

Sources of Fingerlings

- Current productivity and type of fish fingerlings
    - How many fingerlings did you produce in the last year?
- How many outgrowers do you serve?
    - How many farmers could you serve if there was demand (what is your capacity)?
- How do you make fingerlings available to farmers?
- Do you have gaps in the quality of fingerlings produced and how could they be addressed?
    - Would you need help from Gov, consultancies, technical agents etc to improve?

Connectivity and Marketing

- How do you currently market fingerlings and connect with customers?
    - Has this always been the case? How could this be improved?
- What has been the market demand for fingerlings and what are the future prospects? Give reasons for your answer?
    - How many fingerlings did you produce last year? How many were sold?
    - How many fingerlings can you produce per week / month / year currently?

The Future, Increasing Scope and Awareness

- Suggestions for improvements within aquaculture specific sector?

6.4 SMALLHOLDER CLASSIFICATION TABLES

TABLE 2 - COMMERCIAL VIABILITY AND POTENTIAL FOR PERSONAL ACQUISITION OF INPUTS

Number	Qualitative Characteristics	Future Business Expansion Plans	Constraining factors
1	• High level education and technical skills; consultations, internet materials and practical on-farm experience. • Proximity to profitable market; Mzuzu Urban • Proximity to perennial source of water. • Full time employees working on the farm. • Complementary agri-businesses; bananas, soya and beans providing regular, reliable cashflow for investment in aquaculture inputs / production. • Relationship with other smallholder farmers who could be included in his business value chain to supply fish to the market. • Financial capital to expand (currently investing MK1.8million (approx. US$2k) in pond construction). • Has private transport for market and travel. • Well-engineered ponds with water-flow systems.	• Invest in water canals to improve the supply of water from the perennial stream. • Invest in cold room and shop, Mzuzu Urban. • Invest in personal hatchery for production and on-sale of high quality fish fingerlings. • Invest in transport system. • Invest in commercial feed if offered at an affordable price.	• Limited access to commercial feed because of the long distance to Maldeco. • Low temperatures inhibiting fish growth. • In-breeding in ponds, compromising genetic potential of fish. • No bankable business plan to provide a road map for the growth of the business / Needs capacity building in business management / Needs business mentoring and coaching.
2	• High level education and technical skills from involvement in donor funded projects and trainings; exchange programmes including enterprises in Thailand and Nigeria. • Proximity to large market; Lilongwe Urban. • Reliable borehole water using pumps; solar and hydro-electric. • Complementary agri-businesses; livestock and horticulture, restaurant and transport, providing reliable cash flow for re-investment in aquaculture production. • Full-time employees working on farm. • Finance to invest in some commercial feed; informal, private import from Zambia and Maldeco as well as equipment and feed e.g. Artemia from Nigeria for production of catfish. • Access to fingerlings; internal or NAC / Luanar. • Access to extension; professional network with Government Extension workers, friends and Lilongwe University of Agriculture and Natural Resources.	• Investing in a hatchery facility. • Provide fingerlings to smallholders in the surrounding area to improve business. • Expand his business into catfish production.	• No bankable business plan to provide a road map for the growth of the business • Limited access to assured water supply throughout the year. Insufficient water temperature could inhibit growth of fish. • Fewer number of ponds to continuously supply fish to the market.
3	• Well-established businessman; properties. • Higher marketing skills as he is able to access profitable markets e.g. Moyale Barracks, Peoples and Nyama World. • Technical skills on acquired through training; World Vision, NAC	• Plans to invest in poultry production as a source of manure for the fish farming business. • Plans to invest in transport/ delivery	• Needs training on feed formulation and start buying high quality inputs / cheaper sources of manure. • Needs to interact more with other smallholders with an aim to access markets and inputs collectively.

	and AgriTT. • Has ponds (13) for diverse production plan • Has two full time employees at fish farm. • Has well-established office and meeting room. • Has constructed grass shelter for protecting ponds from predators	truck.	• No bankable business plan to provide a road map for the growth of the business. • Needs business mentoring.
4	• Has experienced the benefit of fish farming compared to tobacco and other crops. • Employees full time staff (guards). • Located close to Bunda College where he accesses extension when needed. • Well known by key people in the aquaculture or fisheries sector. • Has a network of vendors who buy fish at the farm gate. • Involved in production of other crops e.g. maize and horticulture. • Has access to adequate water. • Has land to expand his business. • Has received technical support from Bunda and AgriTT project in fish farming. • Has a database of potential customers whom they phone whenever the fish is about to be harvested.	• Construct more ponds. • Wants to learn on how to produce fingerlings. • Wants to organise farmers into groups. • Wants to find customers who would be responsible for transporting and marketing of his fish.	• He lacks marketing skills especially market research as such he relies on vendors or middlemen. This is not advantageous to him because his volume of production is low as such his margins are also low as he shares his margins with the vendors. • Lacks transport to access better markets. • Lacks access to power for storing surplus fish that could not be sold.

TABLE 3 - PARTIAL COMMERCIAL VIABILITY BUT A RECURRING DEPENDENCE ON-FARM INPUTS

Number	Qualitative Characteristics	Future Business Expansion Plans	Constraining factors
5	• Has a passion of her fish farming business • Has attended a number of trainings in fish farming delivered by AgriTT and Aquaculture Enterprise. • Uses family labour (herself plus her two children) in addition to casual labourers. • Largely depend on own formulated feed from maize bran and soya though she did not use soya this year because she did not grow it.	• Plans to buy a car. • Plans to construct more ponds.	• High costs of poultry manure. • Located very far from the main hence incurs more transport costs to access feed, fingerlings and the market. • Has problems of water flow during the other months of the year. • Lack capital to transport fish to profitable markets. • There is scarcity of maize bran due to low production of maize.
6	• Has access to profitable market and is able to sell fish at the best price compared to most farmers. • Has good marketing skills. He is able to market his fish to bank employees, employees from the tea estates and people from within his community.	• Wants to construct more ponds.	• Appears to rely on donor funds to growth or expand business. • Inconsistent access to water throughout the year. • Retired and he may not have the energy to grow the business further.

	• Has livestock that provide him with manure for his two ponds. • Has concrete floors on the eastern edges of his ponds to retain water		
7	• Farms are located close to other fish farmers hence easy for him to work as a group or in an association. • Has some business management skills e.g. owns a grocery shop. • Has access to cheaper sources of manure as rears goats and chickens. • Has formulates own feed using maize bran, soya and sometime pigeon peas and dried small fish pieces.	• Would like to continue with fish farming as a way of spreading the risks from adverse climatic changes.	• Has limited land to construct more ponds. • Does not buy feed and fingerlings but rather recycles fingerlings. • Has problems of accessing extension in fish farming. • Faces competition from capture fisheries from Shire River.

TABLE 4 - COMMERCIALLY NON-VIABLE / ON-FARM FEED AND RECIRCULATION OF FINGERLINGS

Number	Qualitative Characteristics	Future Business Expansion Plans	Constraining factors
8	• Has best land which is closer to the main road. • Has access to perennial water. • An entrepreneur; involved in the poultry and timber business. • Has land which has potential for eco-tourism. • Has access to cheaper sources of manure from poultry business. • Has means of transport. • Willing acquire more knowledge through exchange visits to well established commercial enterprises e.g. Chambo Fisheries. • Farm is located close to Mzuzu Ci. • Willing to take advice from fellow farmers e.g. learnt fish farming from Mrs. Chavula	• No concrete future plans for expanding aquaculture enterprise.	• Despite having very good land, he appears to lacks the drive to manage his fish farm as a business. • Does not buy fingerlings, feed and does not specific time for harvesting his fish. • Improve access to extension in order to acquire more technical knowledge in fish farming. • Needs help harvesting and selling fish.
9	• Has passion to engage in fish farming. • Recognises the benefit of fish farming as she bought goat and fertilizer using funds realised from fish farming. • Uses family labour on her fish farm. • Grows horticultural crops to complement her fish farming business. • Uses leaves from vegetables e.g. pumpkin leaves to feed fish.	• Wants to expand ponds.	• Lacks capital to invest in the business. • Has a very small pond not suitable for commercial purposes. • Does not buy fingerlings and feed. • Solely depends on family labour to do fish farming.

6.5 SMALLHOLDER GROSS-PROFIT MARGIN ANALYSIS

TABLE 5 - GROSS PROFIT MARGIN (GPM) ANALYSIS FOR 150G AVERAGE FISH

Farmers with AgriTT Supported Ponds – 150g Average Fish Weight						
Description	4	2	1	3	5	6
INCOME						
No of ponds – AGRITT Support	1	1	1	1	1	1
Pond Size (m^2)	2000	625	2244	3500	2500	575
Number of fish (density 6/m^2)	12000	3750	13464	21000	15000	3450
Total Net Weight (20% loss) – 150g	1440	450	1615.68	2520	1800	414
Selling Price / kg (MK)	2500	3000	2500	2500	2500	3000
TOTAL INCOME (MK)	**3,600,000**	**1,350,000**	**4,039,200**	**6,300,000**	**4,500,000**	**1,242,000**
EXPENDITURE						
Investment in Pond Expansion	375,000	150,000	1,800,000	320,000	450,000	340,000
Number of employees	2	2	3	2	3	3
Salary / month (MK)	5,000	15,000	2,500	1,538	6,500	20000
Total Annual Salary (MK)	120,000	360,000	90,000	36,923	78,000	240,000
FEEDING						
FCR	2	2	2	2	2	2
Total Kgs required	3600	1125	4039.2	6300	4500	1035
Total Cost of feed (700/Kg)	2,520,000	787,500	2,827,440	4,410,000	3,150,000	724,500
FINGERLINGS						
Total Cost (MK 25 / fingerling)	300,000	93,750	336,600	525,000	375,000	86,250
MANURE						
No of 50kg bags / month	-	3	6	1.2	6	5
Cost / bag (location dependent)	-	1000	500	2500	570	500
Total Cost (MK / 6 months)	-	18,000	18,000	18,000	432,000	15,000
FERTILIZER						

Total Kgs / month	0.5	0	10	40	20	0.3
Number of bags	3	0	1.2	4.8	2.4	2
Cost / bag (MK)	21,000	0	25,000	18,000	28000	11500
Total Cost (MK / 6 months)	63,000	0	30,000	86,400	67,200	23000
Transport (MK - assumption)	30,000	30,000	30,000	30,000	30,000	30,000
TOTAL EXPENDITURE (MK)	**3,408,000**	**1,439,250**	**5,132,040**	**5,426,323**	**4,582,200**	**1,458,750**
GROSS PROFIT (MK)	**192,000**	**-89,250**	**-1,092,840**	**873,677**	**-82,200**	**-216,750**
GROSS MARGIN	**5%**	**-7%**	**-27%**	**14%**	**-2%**	**-17%**
GROSS PROFIT (EXC. EXPANSION)	**567,000**	**60,750**	**707,160**	**1,193,677**	**367,800**	**123,250**
GROSS MARGIN (Exc. expansion)	**16%**	**5%**	**18%**	**19%**	**8%**	**10%**

Farmers with AgriTT Supported Ponds – 75g Average Fish Weight						
Description	**4**	**2**	**1**	**3**	**5**	**6**
INCOME						
No of ponds – AGRITT support	1	1	1	1	1	1
Pond Size (m^2)	2000	625	2244	3500	2500	575
Number of fish (density 6/m2)	12000	3750	13464	21000	15000	3450
Total Net Weight (20% loss)	720	225	807.84	1260	900	207
Selling Price / kg (MK)	2500	3000	2500	2500	2500	3000
TOTAL INCOME	**1,800,000**	**675,000**	**2,019,600**	**3,150,000**	**2,250,000**	**621,000**
EXPENDITURE						
Investment in Pond Expansion (MK)	375,000	150,000	1,800,000	320,000	450,000	340,000
Number of employees	2	2	3	2	3	3
Salary / month (MK)	5,000	15,000	2,500	1,538	6,500	20000
Total Annual Salary (MK)	120,000	360,000	90,000	36,923	78,000	240,000
FEEDING						
FCR	2	2	2	2	2	2
Total Kgs required	1800	562.5	2019.6	3150	2250	517.5
Total Cost of feed (700/Kg)	1,260,000	393,750	1,413,720	2,205,000	1,575,000	362,250

FINGERLINGS						
Total Cost (MK 25 / fingerling)	300,000	93,750	336,600	525,000	375,000	86,250
MANURE						
No of 50kg bags / month	4	3	6	1.2	6	5
Cost / bag (location dependent)	7000	1000	500	2500	570	500
Total Cost (MK / 6 months)	168,000	18,000	18,000	18,000	20,520	15,000
FERTILIZER						
Total Kgs / month	0	0	10	40	20	0.3
Number of bags	3	0	1.2	4.8	2.4	2
Cost / bag (MK)	21,000	0	25,000	18,000	28000	11500
Total Cost (MK / 6 months)	63,000	0	30,000	86,400	67,200	23000
Transport (MK / Assumption)	30,000	30,000	30,000	30,000	30,000	30,000
TOTAL EXPENDITURE (MK)	**2,316,000**	**1,045,500**	**3,718,320**	**3,221,323**	**2,595,720**	**1,096,500**
GROSS PROFIT (MK)	**-516,000**	**-370,500**	**-1,698,720**	**-71,323**	**-345,720**	**-475,500**
GROSS MARGIN	**-29%**	**-55%**	**-84%**	**-2%**	**-15%**	**-77%**
GROSS PROFIT (EXC. EXPANSION)	**27,000**	**-220,500**	**101,280**	**248,677**	**-307,200**	**-135,500**
GROSS MARGIN (Exc. expansion)	**-8%**	**-33%**	**5%**	**8%**	**5%**	**-22%**