WorldFish

Dissemination Strategy for Three Spotted Tilapia in Zambia

October, 2021

With Support From

abacusbio.
BRIDGING SCIENCE & BUSINESS

Citation
This publication should be cited as: WorldFish & AbacusBio. (2021) Dissemination Strategy for Three Spotted Tilapia in Zambia. Penang, Malaysia: WorldFish.

About WorldFish
WorldFish is an international, not-for-profit research organization that works to reduce hunger and poverty by improving fisheries and aquaculture. It collaborates with numerous international, regional and national partners to deliver transformational impacts to millions of people who depend on fish for food, nutrition and income in the developing world. Headquartered in Penang, Malaysia and with regional offices across Africa, Asia and the Pacific, WorldFish is a member of CGIAR, the world's largest global partnership on agriculture research and innovation for a food secure future.

About AbacusBio
AbacusBio is a highly respected science and technology firm operating from offices in Dunedin and Rotorua New Zealand, and Edinburgh, United Kingdom. The firm delivers world class solutions for clients across the agribusiness world.

Acknowledgments
This report was prepared by, and with assistance from: Rose Komugisha Basiita, Patience Chungu, Kelvin Mashisia Shikuku, John AH Benzie, Mr Isaac Phiri, Mr Tom Malambo and Mr Muleya Syapwaya (WorldFish), and Sam Harburg, Gemma Jenkins, Tom Kirk, Bruno Santos, Loame Kok, Megan McCall and Matt Nicholson (AbacusBio).

We also acknowledge the support from Department of Fisheries to access farmers especially the smallholder farmers from the various provinces where the survey was undertaken. Finally the participation of all stakeholder categories in the workshops, without which up to date information on the industry would have been difficult to assimilate.

Contact
WorldFish Communications and Marketing Department, Jalan Batu Maung, Batu Maung, 11960 Bayan Lepas, Penang, Malaysia. Email: worldfishcenter@cgiar.org

AbacusBio 442, Moray Place, Dunedin, New Zealand. Email: info@abacusbio.co.nz

Funded by:

Research supported by:

Table of contents

1. Executive summary

Background & Report Objectives

The Zambia Aquaculture Enterprise Development Project (ZAEDP) was launched by the Government of Zambia in 2017 with funding from the African Development Bank.

As part of ZAEDP, The Zambian government, with support from WorldFish as technical advisors have established a genetic improvement program for Three Spotted Tilapia, a key indigenous Tilapia species perceived to possess good potential for aquaculture production within Zambian production systems. The genetic improvement program seeks to establish the foundation for future supply of genetically improved Three Spotted Tilapia fingerlings (seed) to the Zambian aquaculture industry.

This report comprises the two primary areas of scope described below.

1. Assess the status and potential of the Zambian aquaculture industry, identifying the market opportunity for genetically improved Three Spotted Tilapia seed and subsequent requirements for development of a commercially sustainable breeding program.
2. Identify appropriate industry monitoring systems, data requirements and applicable standards/protocols to support the operations and management of the hatchery sector, particularly the genetic improvement nucleus.

Key Findings – Sustainability of the Three Spotted Tilapia GIP

Table 1 provides a summary of the key findings from the assessment of the commercial sustainability of the Three Spotted Tilapia genetic improvement program (GIP).

Table 1 Summary of key findings – commercial sustainability of the GIP

Topic	Key Findings
Market opportunity for genetically improved Three Spotted Tilapia	• Three Spotted Tilapia is most commonly produced within commercial systems and fills an important niche in regions where the cultivation of Nile Tilapia is not permitted. • Current annual production of Three Spotted Tilapia is approximately 2,000t or 10% of total aquaculture production. • Industry growth outside the Southern province is constrained by a variety of factors including, cost and availability of processed feeds, access to major urban markets, and lack of technical expertise and support. • Most large commercial farms utilise genetically improved strains of Nile Tilapia. These enterprises have been the key source of recent industry growth.

	• To assess the potential demand for genetically improved fingerlings, a range of market growth forecasts were developed. The base, medium growth forecast incorporated an annual growth rate of 11.5% over 20 years. • Under the medium growth forecast, production of Three Spotted Tilapia was forecast to increase to 18,000 t by Y20, with subsequent fingerling demand of 76M fingerlings.
Models for disseminating genetically improved fingerlings to commercial farmers	• Current Three Spotted Tilapia production is supported by a network of hatcheries that are mostly privately owned. • The most efficient model for disseminating genetically improved fingerlings is for the GIP to operate as a genetic improvement nucleus, disseminating broodstock fingerlings to existing (and new hatcheries) that operate as multiplier units. • A licensing model could be adopted to support the transfer of broodstock to the multiplier units. This would incorporate the application of a royalty on sales of commercial fingerlings from the multiplier units as the key revenue stream to support the GIP. • Estimates of the potential on-farm value of genetically improved Three Spotted Tilapia indicate a potential royalty of ZMK 0.15 per fingerling could be applied to the release of the first generation.
Commercial sustainability of the Three Spotted Tilapia GIP	• Utilising the royalty forecasts and market growth projections, a model was developed to forecast the annual profit and loss of the GIP over 20 years (from 2023). • Under medium to higher growth forecasts the GIP could become self- sustaining within 5-8 years. • Consequently, there is a need for ongoing Government or donor support to maintain the GIP until it can reach a point of commercial sustainability. Indicative cumulative support could reach ZMK 16M over 20 years (real 2021 value). • Greater financial support may be required if there is a need for ongoing technical support. • Potential involvement of the commercial sector in the GIP could be pursued but it is unlikely that the GIP could operate on a commercial basis for several years. • The Government needs to clarify its objectives and capacity to support the GIP before engaging further with the commercial sector.

Recommendations - Sustainability of the Three Spotted Tilapia GIP

Based on the above, a series of recommendations (Table 2) have been proposed to progress Government and industry decision making over the continuation of the Three Spotted Tilapia GIP.

Table 2 Recommendations – Sustainability of the Three Spotted Tilapia GIP

Recommendation	Description
Recommendation 1 Performance evaluation and benchmarking	There is an urgent need to undertake further/continuous rigorous performance evaluation and benchmarking of Three Spotted Tilapia to increase farmer awareness and adoption, and better inform policy decisions.
Recommendation 2	There is an urgent need to undertake further wild population surveys of Tilapia distribution to better inform application of biodiversity policies that restrict

Species distribution assessments and policy review	aquaculture use of key species. In addition, there is an urgent need for mapping resources to clarify the current application of these policies.
Recommendation 3 Technical capacity & support	There is an urgent need to consider the requirements for ongoing technical support to the GIP and its implications for investment requirements and commercial sustainability.
Recommendation 4 Cost-benefit analysis and investment strategy	There is a need for a broader cost-benefit analysis across genetically improved seed and other potential industry support interventions to help inform prioritisation of Government investment and resource deployment.
Recommendation 5 Industry consultation to finalise GIP strategy	Government must identify its capacity to continue the GIP and its strategic objectives for continuation of the program. Subject to the above, Government can then engage with the commercial sector to identify the preferred model for ownership and management of the GIP, and appetite for commercial investment/partnership.
Recommendation 6 GIP governance	Subject to continuation of the GIP, an advisory Board or committee should be established to support greater transparency, industry alignment and technical rigour within the GIP. This board should include representation from industry stakeholders and appropriate technical experts.

Key Findings – Industry data systems

Table 3 provides a summary of the key findings from the assessment of the industry data systems required to support the Three Spotted Tilapia genetic improvement program (GIP).

Table 3 Summary of key findings - industry data systems

Topic	Key Findings
Data and information needs for the hatchery sector	• Hatcheries use data to support commercial decisions and genetic improvement. • Commercial industry data is hard to use within genetic evaluations but can inform other important genetic improvement requirements. • The key data requirements to support commercial operations comprise industry data (size and distribution of aquaculture industry), farm systems and farm performance, and hatchery and fingerling production statistics. This data ultimately informs fingerling and market assessments and identifies key segments for fingerling sales and distribution logistics. • The key data requirements to support genetic improvement functions comprise industry data (size and distribution of aquaculture industry), farm systems and farm performance, and market data for harvested fish (pricing, market channels, weights/yields etc). This data supports functions such as shaping nucleus population and population structure, identifying traits to performance record and setting breeding objectives and selection indexes.
Key data gaps for the hatchery sector	• Public data available for the Zambian aquaculture sector predominately comprises the Ministry of Livestock and Fisheries Census, the Department of Fisheries Annual Report, and various research surveys. • ZAEDP has commissioned the development of a fisheries and aquaculture statistics database with support from FAO. The data collection tools have been developed but data is not yet collected, and the system is not operational.

	• A gap analysis identified the key data gaps as comprising farm system and farm performance data, and more robust industry-level statistics. Other data requirements are either adequately covered by existing systems or of lower value to the hatchery sector. • Gaps associated with industry level data largely reflect apparent challenges with survey frequency and repeatability, and apparent inconsistencies created by survey methodologies that impact robustness of the dataset.
Strategies for improved data systems	• It is recognised that resourcing (funding and availability of trained staff) is likely a key constraint impacting current data collection systems. • To manage resource constraints Government can consider less frequent collection to enable more investment into training/support, methodology development, and survey technologies. Strategic outsourcing could also be considered for more complex data. • Survey frequency of biennial (two-yearly) and up to five-yearly may be sufficient for some data types as this frequent enough to retain relevance and support extrapolation of trends. • Industry data systems need to meet the needs of diverse stakeholders. Requirements for the hatchery sector may not align with broader needs of other stakeholders. • FAO CWP guidelines for aquaculture statistics cover the scope of requirements for the Zambian hatchery sector and could form a longer-term target for data collection and reporting systems.

Recommendations – Industry data systems

Based on the above, a series of recommendations (Table 4) have been proposed to progress Government and industry decision making over the scope and requirements for data systems to support the hatchery sector and the GIP.

Table 4 Recommendations - Industry data systems

Recommendation	Description
Recommendation 1 Review scope of ZAEDP survey tools.	Prior to implementation of the FAO survey tools that support the aquaculture statistical database to be commissioned under ZAEDP, an assessment should be undertaken of the scope of these tools to ensure coverage of the urgent gaps identified in this report.
Recommendation 2 Review data collection systems and identify opportunities to improve efficacy.	The Zambian Government should engage with relevant research for development organisations to review broader industry survey systems, methodologies, and staff requirements to support improved efficacy of industry survey systems. This should be in accordance with the strategies described in this report.
Recommendation 3 Develop a long-term data system development strategy.	In concert with Recommendations 1 and 2, the Government should develop a long-term strategy for development of their aquaculture and fisheries statistics. The strategy needs to be supported by cost-benefit analysis to determine the data collection scope, ensuring data collection activities are generating with industry impacts that exceed their cost.

	Industry engagement in the scope and delivery of the strategy is required.
Recommendation 4 Commission the undertaking of a farm-system survey to fill urgent data gap.	Subject to the outcomes from Recommendations 1-3 and the timeliness with which quality farm system data will be collected and reported, Government should commission a detailed farm system survey from relevant research for development organisations and repeat on an agreed interval. This data is a critical gap within the scope of current systems.

2. Introduction

Background

The Government of Zambia commenced the Zambia Aquaculture Enterprise Development Project (ZAEDP) in 2017 with funding from the African Development Bank.

ZAEDP seeks to stimulate the development of the Zambian aquaculture sector to promote economic diversification, food security and sustainable employment generation. Local fish supply is increasingly constrained and dependent on imported fish products to meet shortfalls in local production. With declining output from traditional capture fisheries, local fish production is also increasingly reliant on the aquaculture sector[1].

The project targets development of aquaculture enterprises in identified high potential zones (Siavonga, Chipepo, Bangwelu, Kasempa, Rufunsa and Mungwi) across three key pillars:

1. Provision of support to aquaculture entrepreneurs.
2. Provision of support for development of growth enabling infrastructure.
3. Provision of project management and institutional capacity building.

As a component of Pillar 2, the Zambian Government, with support from WorldFish as technical advisors, have established a genetic improvement program (GIP) for Three Spotted Tilapia (*Oreochromis andersonii*), a key indigenous Tilapia species perceived to possess good potential for aquaculture production within Zambian production systems.

The GIP seeks to establish the foundation for future supply of genetically improved Three Spotted Tilapia fingerlings (seed) to the Zambian aquaculture industry, particularly farmers in areas where aquaculture production is reliant on indigenous species.

Objectives

This report, prepared in partnership by WorldFish and AbacusBio, describes opportunities for the Government of Zambia to support the development of a sustainable hatchery sector for ongoing production of genetically improved Three Spotted Tilapia seed.

Availability of genetically improved seed could support increased aquaculture productivity and stimulate industry growth via the availability of improved strains that offer commercial farmers superior performance across economically important traits such as growth, survival, disease resistance and feed conversion efficiency.

[1] African Development Bank (2016), Zambia aquaculture enterprise development project: project appraisal report.

The report will comprise the two primary areas of scope described below.

1. Assess the status and future potential of the Zambian aquaculture industry and use this assessment to identify the market opportunity for genetically improved Three Spotted Tilapia seed. Based on the identified market opportunity, the report will subsequently describe requirements for the development of sustainable business models for the Three Spotted Tilapia hatchery sector (including a genetic improvement program) in Zambia.
2. Identify appropriate industry monitoring systems, data requirements and applicable standards/protocols to support the operations and management of the hatchery sector, particularly the genetic improvement nucleus. This will comprise identification of the key data and information needs of the sector, which, when fulfilled, will enable the production of a supply of quality seed that aligns with industry needs.

3. Industry Snapshot

Fish Supply and Demand in Zambia

Fish accounts for over 55% of animal protein consumption in Zambia, with estimated consumption of 11kg/capita in 2014[2]. Consumption of fish is well below the global average of 20kg/capita and is a key factor in nutritional deficiencies prevalent among rural and poorer demographics within Zambia[3].

Figure 1 highlights current fish supply and demand dynamics within Zambia, demonstrating that fish supply has become increasingly reliant on imported fish to support the increased demand of a growing population. Capture fisheries have traditionally provided the majority of Zambia's local fish supply for the last 25 years. However, the overall production of capture fisheries has since stagnated due to over-fishing and subsequent imposition of fishing regulations.

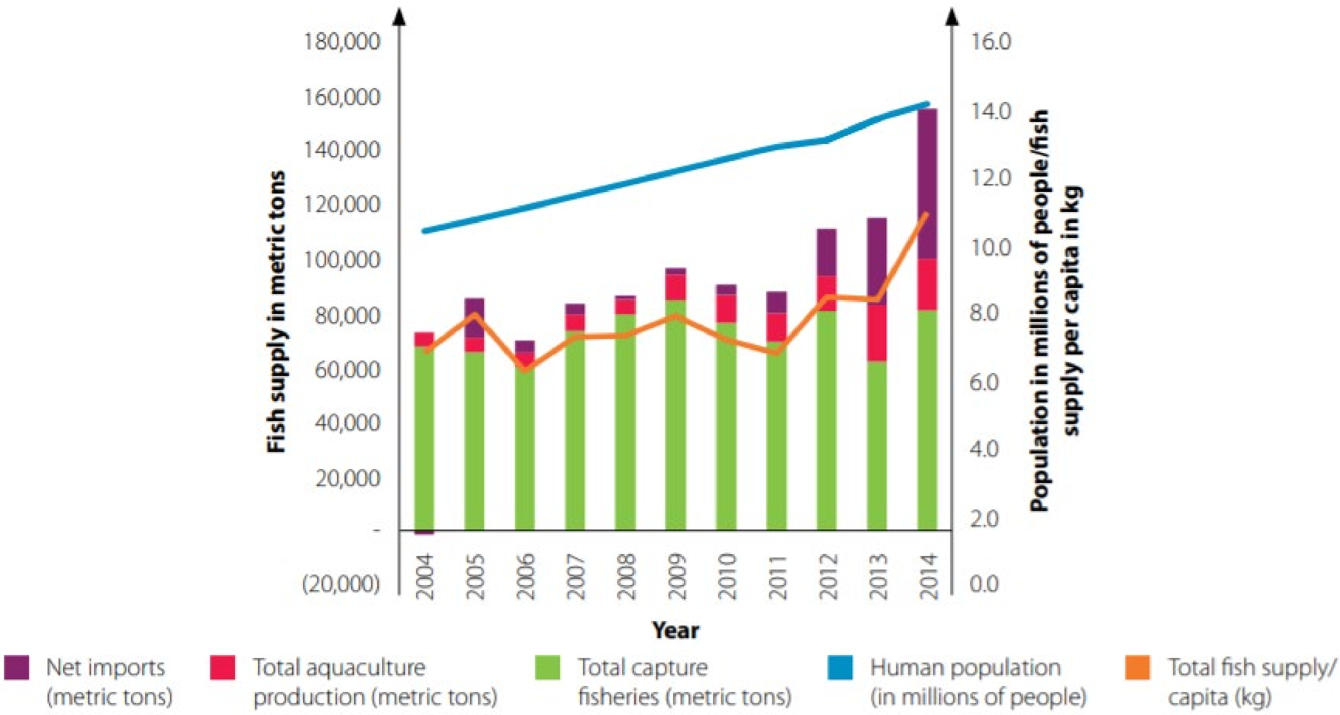


Figure 1 Fish supply and demand in Zambia[4]

[2] Tran et al (2019) Fish supply and demand for food security in Sub-Saharan Africa: An analysis of the Zambian fish sector, Marine Policy, 99, pp 343-350.

[3] Marinda PA, Genschick S, Khayeka Wandabwa C, Kiwanuka-Lubinda R, Thilsted SH (2018) Dietary diversity determinants and contribution of fish to maternal and under-five nutritional status in Zambia. PLoS ONE 13(9): e0204009. https://doi.org/10.1371/journal.pone.0204009

[4] Figure sourced from: Genschick S, Kaminski AM, Kefi AS and Cole SM. 2017. Aquaculture in Zambia: An overview and evaluation of the sector's responsiveness to the needs of the poor. Penang, Malaysia: CGIAR

Per capita consumption of fish had exhibited a steady decline from 16.5kg in 1971 to 6.2kg in 2000[5], however recent increases of fish imports have supported rising consumption rates due to greater availability of fish.

Imported fish and fish products are sourced from both neighbouring/nearby countries, and international sources, particularly China. Fish imports by many African countries have surged sharply in recent years and if current production, consumption, and trade trends continue, 50% of fish for human consumption in Africa is projected to be met by imported fish products by 2050[2]. Africa has become China's second most important tilapia export market after the United States.

Zambia is currently the 4th largest aquaculture producer (in mt) in Sub-Saharan Africa and 6th in Africa overall. Figure 2 depicts the extent of historical growth in Zambian aquaculture production, highlighting the transition from an industry dominated by smallholder enterprises to a sector that is increasingly reliant on larger, commercial enterprises and undergoing rapid growth.

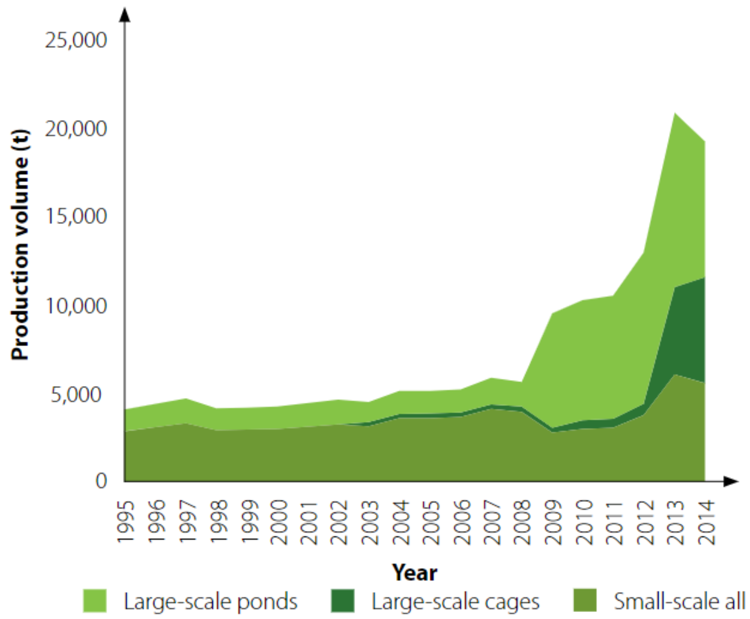


Figure 2 Trends in Zambian aquaculture production[6]

The recent growth in the Zambian aquaculture sector provides a foundation for the sector to play an increasingly important role as a key source of fish to the Zambian population. Zambia possesses abundant land/water resources and a climate suitable for aquaculture, coupled with a growing population that readily consumes fish. Scope exists for ongoing expansion of the sector if provided with an appropriate enabling

Research Program on Fish Agri-Food Systems and Lusaka, Zambia: Department of Fisheries. Working Paper: FISH-2017-08.

[5] Republic of Zambia (2004), National aquaculture strategy

[6]Figure sourced from: Genschick S, Kaminski AM, Kefi AS and Cole SM. 2017. Aquaculture in Zambia: An overview and evaluation of the sector's responsiveness to the needs of the poor. Penang, Malaysia: CGIAR Research Program on Fish Agri-Food Systems and Lusaka, Zambia: Department of Fisheries. Working Paper: FISH-2017-08.

environment. Initiatives that promote greater access to improved feed and seed, in conjunction with value chain development and technology transfer, can further enhance the contribution of the sector to food security[6].

Aquaculture Production in Zambia

Aquaculture occurs in most of Zambia's ten provinces; however, the Southern province represents the key industry hub as depicted in Figure 3.

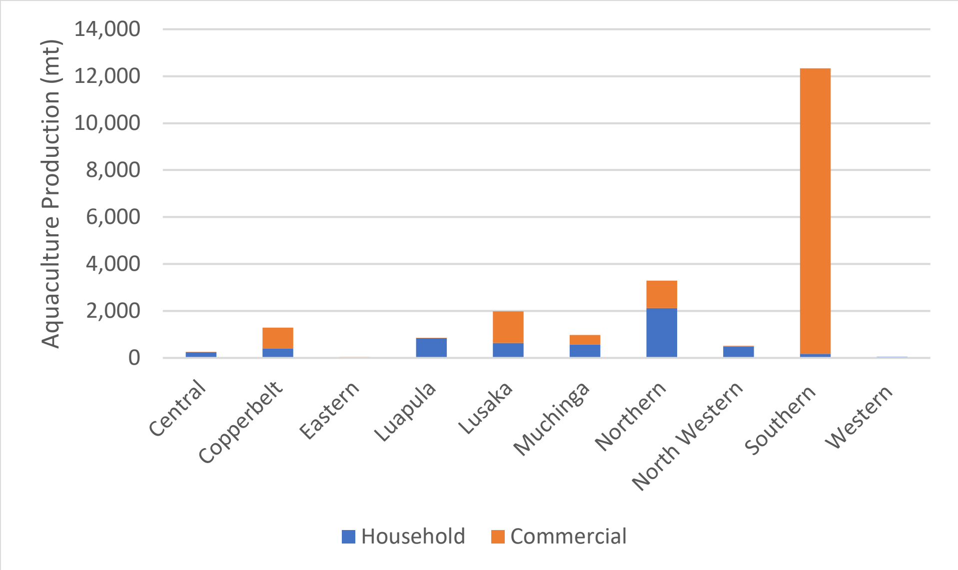


Figure 3 Distribution of Zambian aquaculture production[7]

In 2017, commercial enterprises were responsible for 74% of aquaculture output and have been the key source of industry growth since 2007.

The Ministry of Fisheries and Livestock reports that there are approximately 9,615 households engaged in aquaculture as of 2017[7]. Household enterprises are distributed nationally but predominate within Luapula, Muchinga, Northern and North Western provinces (collectively these provinces contain over 70% of household aquaculture enterprises).

Household production is mostly pond based. Productivity of household enterprises ranges from 1t – 1.5t/ha under extensive systems with limited availability of inputs (seed, feed and fertilizer), up to 4.5t/ha under better performing systems and where inputs are less limiting. It is estimated that only 9% of smallholders achieve annual yields in excess of 4.5t/ha[8].

There is limited data available on the profitability of household enterprises. Given the lack of growth in output from the household sector in Figure 2, and the proportion of unstocked/abandoned household facilities reported by the Ministry of Fisheries and

---

[7] Ministry of Fisheries and Livestock (2019), The 2017/2018 Livestock and Aquaculture Census

[8] Genschick S, Kaminski AM, Kefi AS and Cole SM. 2017. Aquaculture in Zambia: An overview and evaluation of the sector's responsiveness to the needs of the poor. Penang, Malaysia: CGIAR Research Program on Fish Agri-Food Systems and Lusaka, Zambia: Department of Fisheries. Working Paper: FISH-2017-08.

Livestock[9], it is possible that profitability is marginal/poor within this segment. This is consistent with farmer survey responses (see Part 2) highlighting numerous key challenges for smallholder farmers associated with availability of seed and feed, challenging market access and lack of technical expertise[7].

Within the commercial segment it is estimated that there are approximately 126 aquaculture establishments or larger commercial farms, hatcheries, and nurseries[7]. The commercial industry is dominated by several larger companies: Yalelo, Lake Harvest, Kalimba Farms and Kafue Fisheries, most of whom operate vertically integrated businesses. Several of the large companies have established partnerships and joint ventures with major international companies to strengthen access to critical supplies of feed and seed.

By contrast to household systems, commercial farms comprise a mix of intensive commercial ponds and cage systems that are located within major waterbodies such as Lake Kariba. Productivity of commercial farms is significantly higher with commercial enterprises typically achieving yields of 15t-20t/ha[8].

As depicted in Figure 3, commercial production is centred around the Southern Province, this reflects several key factors, including:

- The availability and suitability of Lake Kariba for intensive cage culture. Lake Kariba provides access to warmer water sites that support higher levels of productivity during winter[10].
- The proximity of the region to major markets in Lusaka, and key infrastructure that facilitates improved market access.
- The concentration of intensive operations enables co-location with critical support enterprises (hatcheries/nurseries and feed mills).
- The ability to utilise improved, non-indigenous species such as Nile Tilapia (*Oreochromis niloticus)* for aquaculture production.

The latter reflects the enforcement of a biodiversity policy that restricts the use of aquaculture species to watersheds where they are either indigenous or otherwise endemic. The policy currently restricts the use of Nile Tilapia to the Southern and Lusaka provinces. Consequently, indigenous species such as Three Spotted Tilapia and Green Headed Tilapia (*Oreochromis macrochir*) represent the primary aquaculture species for farmers outside the Southern and Lusaka provinces, though these indigenous species are similarly restricted to regions in which they are native or endemic.

Figure 4 displays a breakdown of Zambian aquaculture production by species (based on 2017 data).

[9] Ministry of Fisheries and Livestock (2019), The 2017/2018 Livestock and Aquaculture Census

[10] Moyo N and Rapatsa M (2021), A review of the factors affecting tilapia aquaculture production in Southern Africa, Aquaculture, 535.

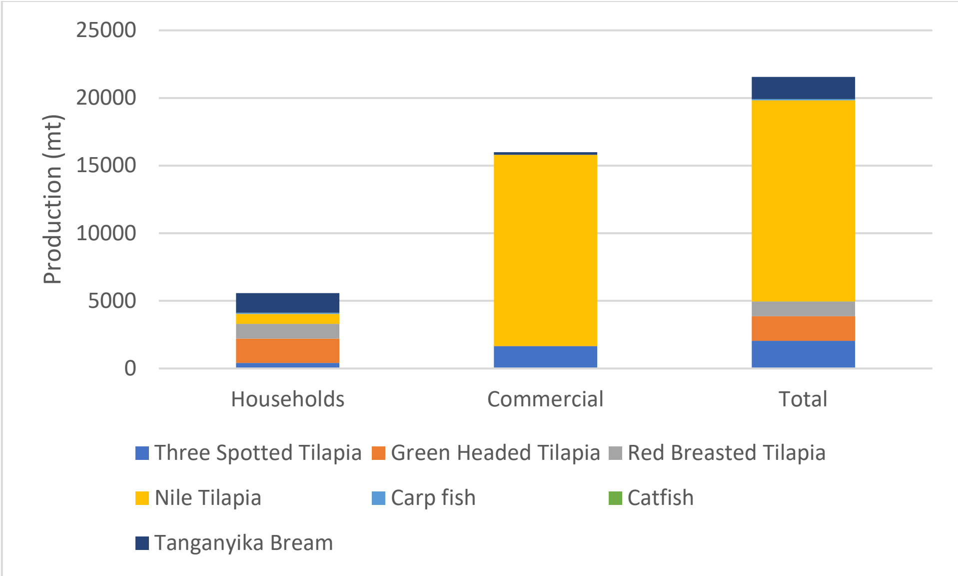


Figure 4 Composition of Zambian aquaculture production in 2017[11]

Choice of aquaculture species is more diverse within household systems, with greater reliance on indigenous Tilapia species, particularly Green Headed Tilapia (*Oreochromis macrochir*), Tanganyika Bream (*Oreochromis tanganice*), and Red Breasted Tilapia (*Tilapia rendalli*).

By contrast, the commercial segment extensively utilises the non-indigenous Nile Tilapia, in conjunction with Three Spotted Tilapia. This reflects a preference for Nile Tilapia by the commercial industry and may partly explain the concentration of commercial producers within regions where cultivation of Nile Tilapia is permitted. Other factors may also include:

- Greater availability of broodstock and seed, particularly from genetically improved strains.
- Superior performance (or perceived superior performance) relative to alternate species, particularly in commercial systems.
- Greater availability of technical expertise, specialised inputs (formulated feeds and aquatic health products) and technical performance data that reflects the widespread global production of Nile Tilapia.

Three Spotted Tilapia, the target species for the GIP established under ZAEDP, is estimated to contribute 2,054mt or 10% of national aquaculture production. Approximately 1,647mt is produced within the commercial sector[11].

Due to the limited production of Three Spotted Tilapia outside of Zambia, there is a limited pool of published data comparing the performance of Three Spotted Tilapia against commercial (genetically improved) strains of Nile Tilapia. Some local

[11] Ministry of Fisheries and Livestock (2019), The 2017/2018 Livestock and Aquaculture Census

comparisons have reported comparable performance between the two species[12,13]. However, it is not certain that this incorporated a comparison between Three Spotted Tilapia and a genetically improved strain of Nile Tilapia as other studies have reported distinct growth rate advantages for Nile Tilapia[14,15].

Development of a commercially viable market for genetically improved Three Spotted Tilapia seed will require greater uptake from commercial enterprises. This will only occur with more comprehensive performance benchmarking against improved strains of Nile Tilapia under commercially relevant systems.

Aquaculture Value Chains and Key Actors

Figure 5 describes the structure, segmentation, and key actors within the Zambian aquaculture value chain[16]. The fisheries and aquaculture value chain is a key source of employment within Zambia, providing income for 13,000 people[17].

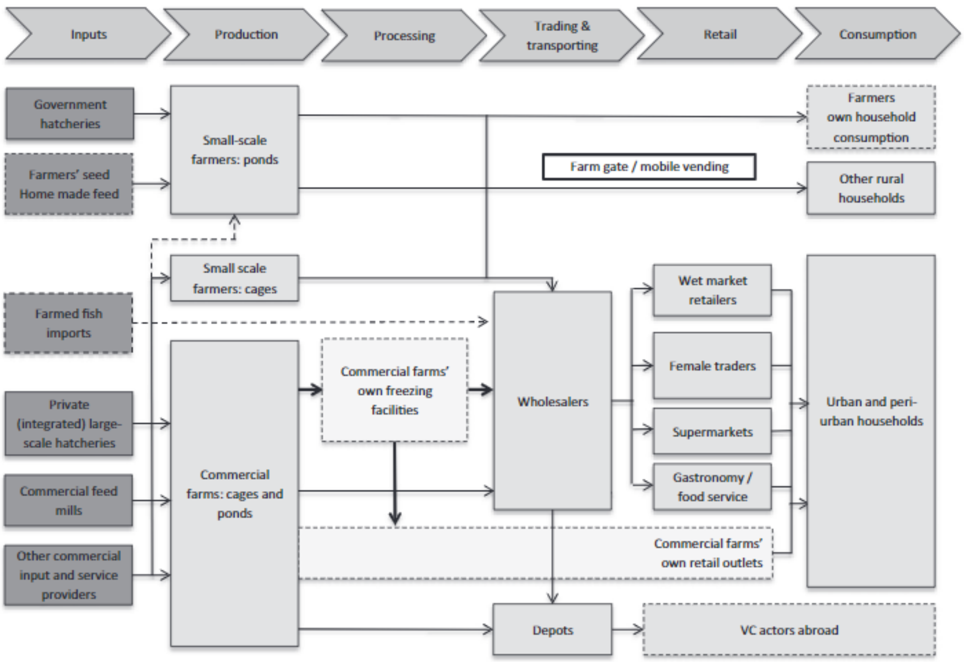


Figure 5 Structure of the Zambia aquaculture value chain[16]

[12] Cayron-Thomas, E (2010), Comparison trials between Oreochromis andersonii (Kafue Bream) and O. niloticus (imported species) under farm conditions in Zambia, EC FP7 Project, SARNISSA
[13] Kefi, A & Mwango, J (2018), Is the culture of exotic fish species the answer to low fish productivity? A case study on the use of Oreochromis niloticusin Zambia, International Journal of Fisheries and Aquaculture, 10 (11), pp 129-139.
[14] Bowerbank Day, S (2015), A Growth Comparison Among Three Commercial Tilapia Species in a Biofloc Technology System in South Africa, Thesis presented in partial fulfilment of the requirements for the degree of Master of Science in the Faculty of AgriSciences at Stellenbosch University.
[15] Simataa, S & Musuka, C (2013), Impact of Withdrawing Oreochromis niloticus (Nile Tilapia) from Aquaculture Production in Zambia: A Case Study of Solwezi District, International Journal of Aquaculture, 3 (27), pp 158-164.
[16] Figure sourced from: Kaminski, A.M., Aquaculture (2017), https://doi.org/10.1016/j.aquaculture.2017.12.010
[17] Genschick S, Kaminski AM, Kefi AS and Cole SM. 2017. Aquaculture in Zambia: An overview and evaluation of the sector's responsiveness to the needs of the poor. Penang, Malaysia: CGIAR Research Program on Fish Agri-Food Systems and Lusaka, Zambia: Department of Fisheries. Working Paper: FISH-2017-08.

As depicted above (Figure 5) the structure of the value chain is distinct for the household sector relative to the commercial sector.

Generally, household aquaculture is undertaken primarily for subsistence, with opportunistic marketing of surplus fish that exceeds household needs[18,19]. Surplus fish are sold locally via traditional, local markets and pondside.

Commercial scale aquaculture supplies fish to consumers within urban markets in Lusaka and Copperbelt provinces. Traders such as Capital Fisheries Ltd provide cold chain and transport logistics to support distribution[18]. Larger commercial producers are starting to invest in their own processing and cold storage infrastructure[20]. Generally, cold chain infrastructure is only available in urban centres, limiting distribution of fish (or restricting availability to smoked or dried products) in more remote regions[19.]

Marketed fish are graded by weight with higher prices (ZMW/kg) achieved by heavier grades. Imported Tilapia from China is typically priced below locally produced Tilapia but is also generally only available in lighter product grades, indicating that imported Tilapia are generally being consumed by lower-income consumers[18].

Supporting the growth and development of the commercial sector has been the emergence (since 2015) of a growing aqua feeds industry. The industry is centred around the needs of the commercial producers in the Southern Province. Current reliance on imported micro-nutrients results in relatively high prices for commercial feeds, which in combination with very high freight costs and limited technical support, results in low adoption of processed feeds from household farmers[21].

Hatchery Sector & Seed Production

Zambian aquaculture is currently serviced by a network of hatcheries that comprise three primary hatchery models:

1. A network of 18 Government-owned hatcheries that produce seed from native Tilapia strains.
2. Private hatcheries that specialise in seed production and sale.
3. Private hatcheries that operate as part of large, vertically integrated operations and primarily produce seed for internal use.

It is estimated that over 70% of the hatchery sector is privately owned[22].

---

[18] Kaminski, A.M., Aquaculture (2017), https://doi.org/10.1016/j.aquaculture.2017.12.010
[19] Genschick S, Kaminski AM, Kefi AS and Cole SM. 2017. Aquaculture in Zambia: An overview and evaluation of the sector's responsiveness to the needs of the poor. Penang, Malaysia: CGIAR Research Program on Fish Agri-Food Systems and Lusaka, Zambia: Department of Fisheries. Working Paper: FISH-2017-08.
[20] See: https://www.lakeharvest.com/
[21] Genschick S, Kaminski AM, Kefi AS and Cole SM. 2017. Aquaculture in Zambia: An overview and evaluation of the sector's responsiveness to the needs of the poor. Penang, Malaysia: CGIAR Research Program on Fish Agri-Food Systems and Lusaka, Zambia: Department of Fisheries. Working Paper: FISH-2017-08.
[22] Basiita K, Kakwasha K, Chungu P, Malambo T, Trinh T, and Benzie J (2020), Report on Species Mapping, Purity in Hatcheries and Review of Best Management Practices

In addition to these hatchery sources, many household farmers also produce their own seed, source seed from wild populations, or source from other household farmers[23]. Generally, household farmers rely on the Government hatcheries for seed inputs in addition to these other sources.

Seed output is dominated by the private hatcheries, with Government hatcheries only producing 500,000 fingerlings in 2015[23], by contrast the largest private hatchery is estimated to sell over 15M fingerlings per cycle[24].

Private hatcheries typically favour the production of Nile Tilapia, reflecting the demand from the commercial sector of the industry. Some private hatcheries produce Three Spotted Tilapia, either as the sole species or in combination with other species. The largest commercial Three Spotted Tilapia hatchery is estimated to produce 2M fingerlings per cycle[24].

Genetically improved seed is only available for Nile Tilapia, relying on imported broodstock from major international genetic improvement programs[25] continuation of which is impacted by current restrictions on imported broodstock due to TiLV risks. Alternate sources outside of the larger Nile Tilapia hatcheries utilise unselected brood populations developed from wild stock. The genetic improvement program for Three Spotted Tilapia will provide an important source of genetically improved seed for a key indigenous species that support enhanced production across a broader segment of Zambia.

[23] Kaminski, A.M., Aquaculture (2017), https://doi.org/10.1016/j.aquaculture.2017.12.010
[24] Basiita K, Kakwasha K, Chungu P, Malambo T, Trinh T, and Benzie J (2020), Report on Species Mapping, Purity in Hatcheries and Review of Best Management Practices
[25] See: https://www.benchmarkplc.com/benchmarks-spring-genetics-signs-agreement-with-africas-largest-integrated-tilapia-producer-lake-harvest/

4. Stakeholder Perspectives

Background and Methodology

As identified in Part 1, current production of Three Spotted Tilapia is estimated to be 2,054t per year. A commercially sustainable genetic improvement will likely require a more substantial commercial industry to underpin demand for genetically improved fingerlings.

Stakeholder perspectives on industry growth opportunities and Three Spotted Tilapia demand were obtained via surveys and consultative workshops undertaken between July and September 2021.

Respondents from among household and commercial-scale fish farmers, Government Fisheries staff, aquaculture researchers/academia and members of development agencies were asked to provide their views and opinions on the following key topics:

- The potential for aquaculture industry growth in Zambia.
- Perceptions of Three Spotted Tilapia as a key aquaculture species and its importance to industry growth.
- Major barriers and challenges to industry growth and the priorities for Government support and intervention.

Consultative workshops were held to obtain stakeholder feedback on survey results and better understand their perspectives. Due to restrictions associated with the COVID-19 pandemic, these workshops were limited to online participation which prevented the participation of household aquaculture stakeholders. However, perspectives from remote household farmers were engaged via phone interviews and phone surveys administered by enumerators with support from the Provincial Fisheries Officers.

Survey responses were received from 73 (49 complete responses) household and commercial farmers from all provinces of Zambia. In addition, a further 68 (39 complete) responses were received from stakeholders from among Government staff, aquaculture researchers/academia and members of developmental organisations.

Survey results from household and commercial farmers and other stakeholders are provided within Annex 1. Questions containing sensitive information from respondents have been removed to adhere to regulations of research under the Government of Zambia research ethics body and WorldFish ethics policies on confidentiality.

Figure 6 provides a summary of the scale and primary aquaculture species produced by the household and commercial farmer respondents.

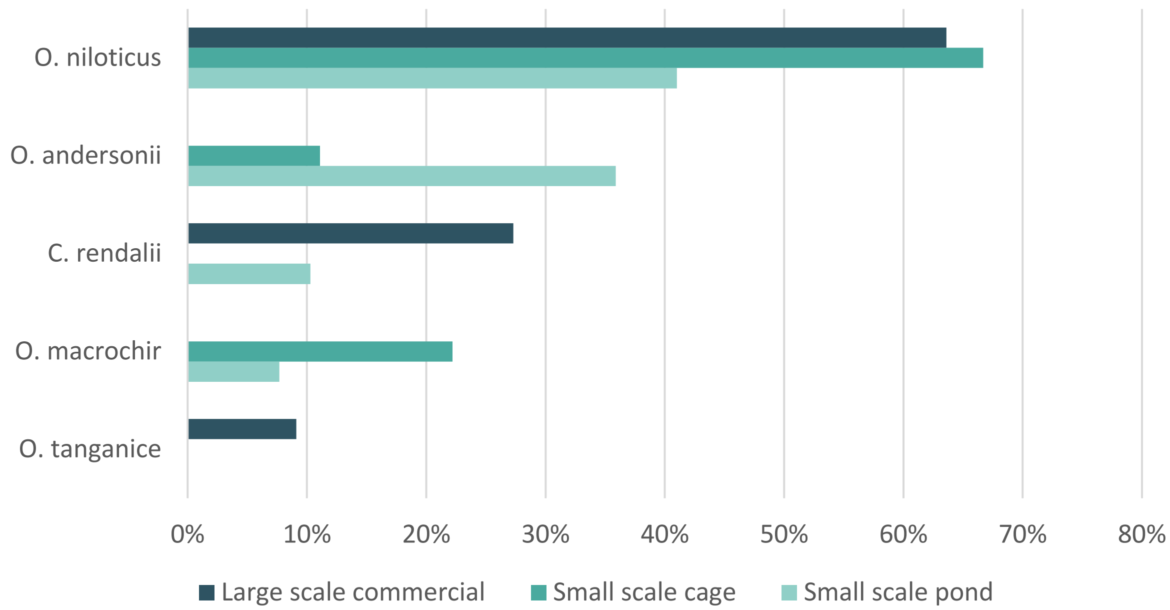


Figure 6 Summary of farmer respondents to stakeholder survey

In addition to Figure 6, other key demographic descriptors of the survey respondents comprised:

- Farmer respondents were drawn from all provinces of Zambia.
- 89% of respondents were small-scale, household farmers.
- 85% of non-farmer respondents were Government employees across regulatory and policy functions, research, academia, extension and parastatal areas.

Industry Growth Potential

Most farmer survey respondents and workshop participants believed that the industry has significant potential to grow (Figure 7).

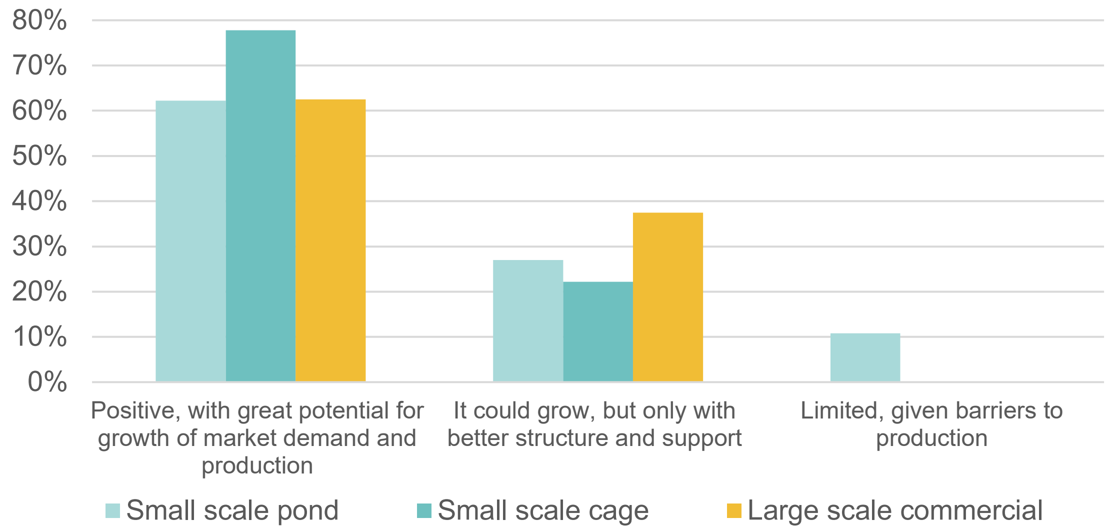


Figure 7: What do farmers believe to be the outlook for the aquaculture industry in Zambia?

Nearly 63% of commercial farmers believed the outlook of the industry to be positive, with great opportunities for growth and market production. Non-farmer stakeholders also held positive views about industry growth potential – 84% believing there is strong potential for growth.

These results reflected strong Zambian consumer preferences for fish and large capacity to increase aquaculture output and efficiency. Competition with imported fish was not viewed as a major challenge/risk with stakeholders believing that local product is generally preferred, and imports are opportunistically filling demand that cannot be satisfied by local supply. Stakeholder views of key opportunities for industry growth are summarised in Figure 8.

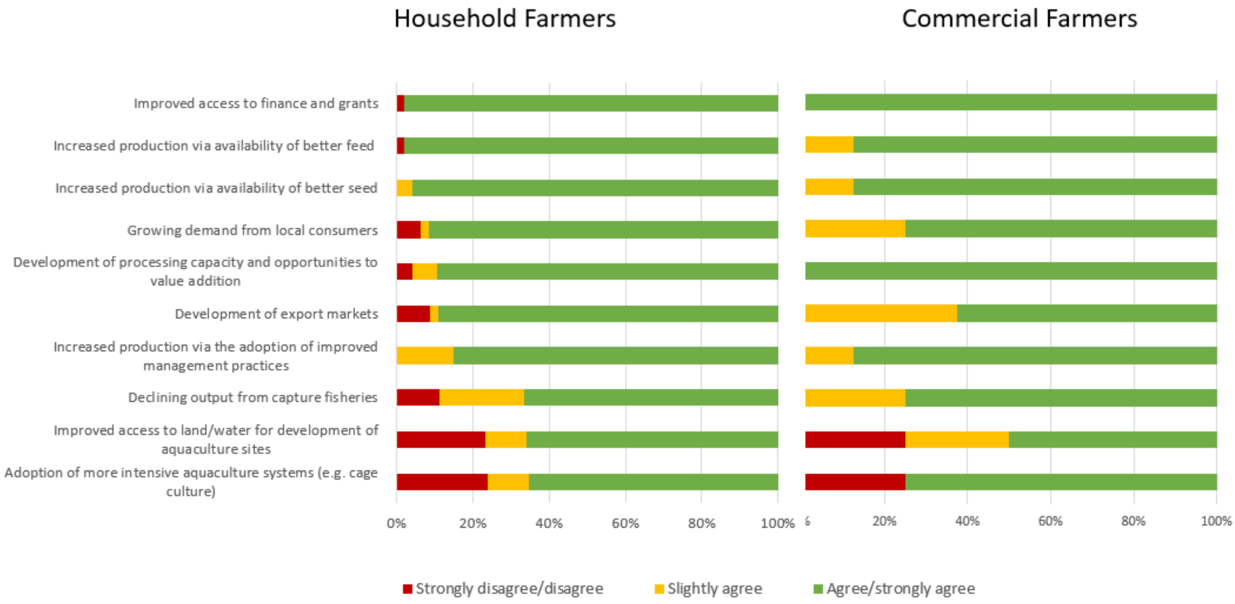


Figure 8 Farmer perceptions of key opportunities for industry development

Across all stakeholders, the Southern and Luapula provinces were nominated as the regions with greatest potential to increase aquaculture production. Key factors identified within the workshops as shaping the growth potential of specific regions comprised:

- Availability of surface water suitable for aquaculture development.
- Ability to cultivate Nile Tilapia (see later in report).
- Climate, particularly water temperatures that are conducive to good winter growth rates.
- Proximity to major markets and population centres.
- Proximity to major feed processors and hatcheries.

The commercial sector is generally viewed as the most obvious source of industry growth, consistent with historical trends reported in Figure 2. Stakeholders viewed the potential for growth within the household sector as more dependent on enablers such as improved access to key inputs (fingerlings and feed), access to finance, development of technical expertise and support, and greater opportunities to access major urban markets. Transport distances and infrastructure are major challenges affecting access to key inputs and key markets within remote provinces.

Commercial farmers viewed the Southern province as the most favourable region for commercial-scale aquaculture due to proximity to markets and feed processors, access to Nile Tilapia, and warmer water temperatures, particularly within Lake Kariba.

Opportunities for growth in production of Three Spotted Tilapia

Approximately 67% of surveyed farmers and 86% of other stakeholders viewed Three Spotted Tilapia as being an important species for the development of the Zambian aquaculture industry. Figure 9 and Figure 10 highlight stakeholder perceptions of Three Spotted Tilapia.

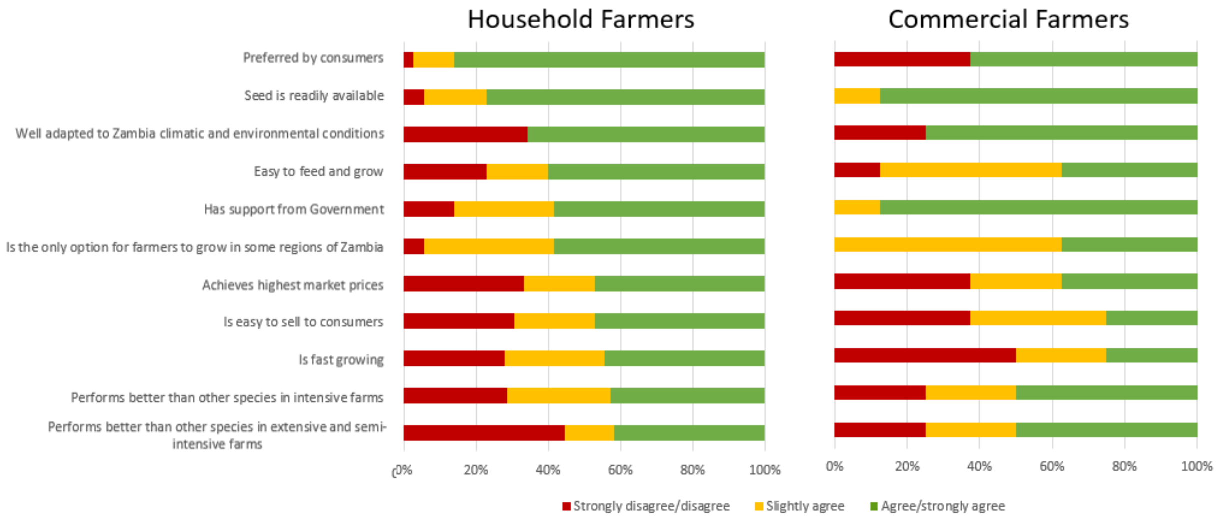


Figure 9 Household and Commercial farmer perceptions of Three Spotted Tilapia

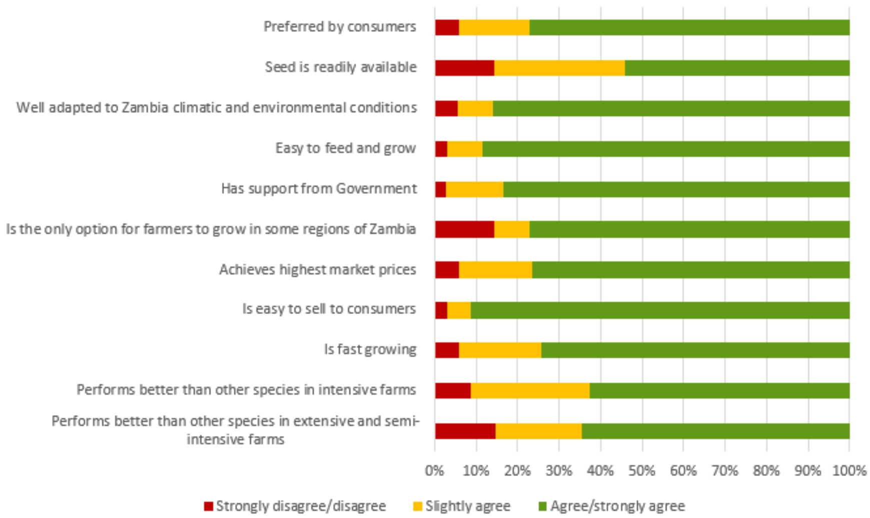


Figure 10 Government, research/academia and other stakeholder perceptions of Three Spotted Tilapia

Stakeholders believe that Three Spotted Tilapia has good potential to contribute to development of the industry. It is seen as a productive indigenous Tilapia species, with good adaption to local conditions. It will offer farmers outside the Southern and Lusaka provinces a viable, genetically improved alternative to Nile Tilapia. The species is also readily consumed by local consumers.

Stakeholders were asked within the workshops about the potential performance advantages of Three Spotted Tilapia:

- Non-farmer stakeholders (Government, research/academia, and developmental agency) believed that performance of Three Spotted Tilapia could be superior, particularly in colder climates and more extensive systems (see earlier discussion in Part 1 about published comparisons).
- Farmer stakeholders generally believed that Nile Tilapia offered superior growth and feed conversion performance. Farmers who had undertaken on-farm trials reported up to 50% higher growth for Nile Tilapia[26].

These results and observations highlight potential challenges gaining market share for Three Spotted Tilapia, particularly among commercial farmers who predominantly grow Nile Tilapia.

Stakeholders believed that the availability of Three Spotted Tilapia seed was a key factor limiting production of the species, along with its sensitivity to being handled. A genetic improvement program, coupled with more in depth research and development and increased seed availability (potentially supported by more dispersed hatcheries and nurseries) was viewed as a key opportunity to drive increased production of the species in many regions.

Key Opportunities and Barriers to Industry Growth

Stakeholders were asked to identify key opportunities and barriers to growth of the aquaculture industry. Barriers to industry growth and development are identified in Figure 11.

[26] A large commercial farmer reported the results of an on-farm trial where Three Spotted Tilapia yielded 10.7t/ha compared to 16.2t/ha for genetically improved Nile Tilapia.

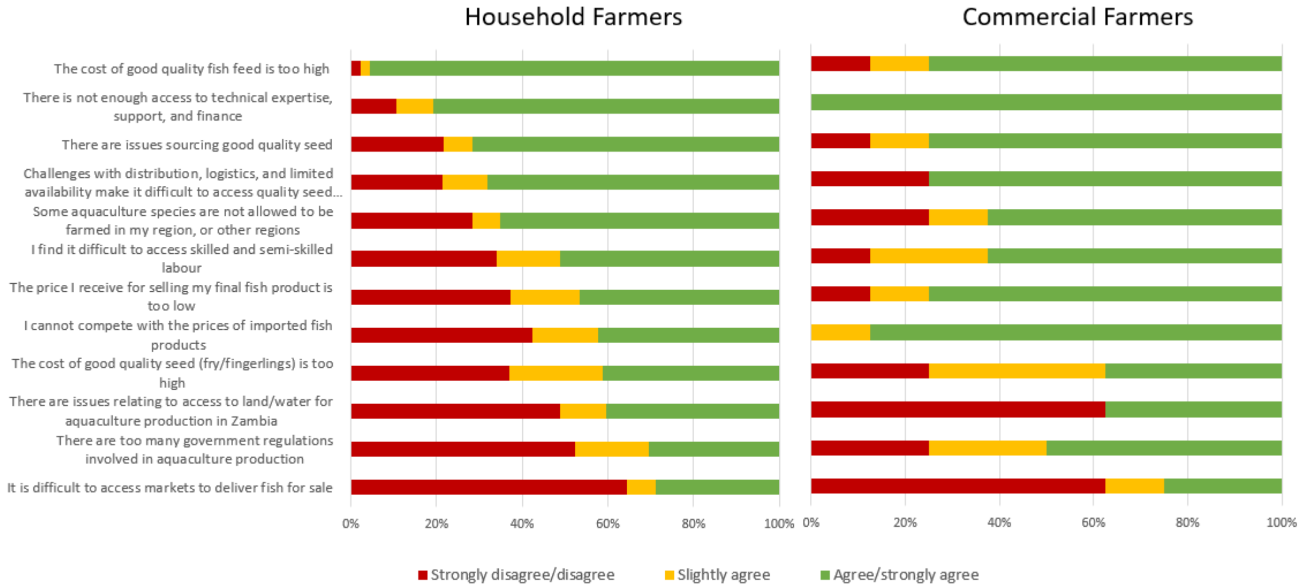


Figure 11 Farmer perceptions of industry barriers

Stakeholders believed that aquaculture production is affected by a broad range of inter-related barriers predominately comprising access to critical inputs (feed and good quality seed), access to finance to source inputs, and lack of technical support to facilitate adoption of improved farming practices.

It is generally believed that these barriers become more prevalent in more remote regions due to the high freight costs to transport feed, lack of nearby hatcheries/nurseries and high fingerling transit mortalities, and lack of access to technical support.

Hatcheries and breeding program development is a key area where stakeholders see opportunity for Government support and leadership, particularly in initial stages. This is driven by the perception that the industry is largely constrained by restricted access to fingerlings, particularly of improved and indigenous fish species - with almost 80% of farmers (both smallholder and commercial producers) believing that limited access to seed is a major constraint for fish production in Zambia.

Summary of Key Findings

The surveys and workshops highlighted a positive view for the growth and development of the aquaculture industry in Zambia. A summary of stakeholder views relating to both the potential for growth in the aquaculture industry and potential demand for Three Spotted Tilapia is presented in Table 5.

Table 5 Assessment of market growth potential for Three Spotted Tilapia in Zambia

Market Parameter	Growth Assessment
Factors affecting the growth and development of the aquaculture industry	✓ Strong recent industry growth rates observed. ✓ Abundant land and water resources suitable for aquaculture development. ✓ Established and growing commercial sector driving industry growth. ✓ Value chain is developing to support commercial sector – major feed companies have established operations in Zambia, while processing and downstream sectors are starting to establish. ✓ Strong demand for fish from local consumers – key protein source within local diets. × Industry growth is very localised, centred on the Southern province. Difficult to access inputs and markets in more remote regions. × Output from Household farmers has not demonstrated any recent growth. Sector is constrained by lack of technical expertise/support, lack of finance and poor availability of critical inputs. × Limited Government resources to support industry growth, particularly among household and semi-commercial farmers in more remote regions.
Factors affecting the demand and potential market share for Three Spotted Tilapia	✓ Indigenous species such as Three Spotted Tilapia are currently the only option available to farmers outside Southern and Lusaka provinces. ✓ Three Spotted Tilapia will comprise the only genetically improved indigenous species available in Zambia (following the release of improved germplasm from the GIP). ✓ Stakeholders believe that Three Spotted Tilapia may outperform Nile Tilapia in colder environments within higher altitude regions of Zambia. However there is currently no, or limited evidence, to support this perception. ✓ Ongoing access to new strains of genetically improved Nile Tilapia broodstock is currently impacted by importation restrictions imposed to manage biosecurity risks (Tilapia Lake Virus). ✓ Stakeholders were supportive of the GIP and believed the improved seed would be valuable to farmers. × Future industry growth is likely to be driven by the commercial sector. This sector has demonstrated strong preference for developing aquaculture operations in Southern regions (for environmental and commercial/logistical benefits). × Several larger commercial farmers accessing genetically improved strains of Nile Tilapia reported 50% higher production than Three Spotted Tilapia in on-farm trials. Commercial farmers perceive improved strains of Nile Tilapia to be vastly superior to Three Spotted Tilapia. × Household and semi-commercial farmers are a challenging market for improved seed. Historically there has been little growth in this sector. Sector is constrained by lack of finance and technical expertise, as well as access to key inputs. Farmers traditionally collect/breed some of their own seed to minimise costs. × Difficult to make seed accessible for all farmers, even from dispersed multiplier hatcheries, due to the transportation distances and subsequent freight costs and transit mortalities. × Biosecurity policy restricting the culture of Nile Tilapia outside the Southern and Lusaka provinces could be removed if wild populations of Nile Tilapia extend into other watersheds. This could reduce demand for Three Spotted Tilapia seed.

5. Business Models for a Sustainable Three Spotted Tilapia Breeding Program in Zambia

Models for Delivery of Three Spotted Tilapia Improved Seed

Current production of Three Spotted Tilapia is underpinned by seed produced within a network of predominately privately owned hatcheries. Any dissemination strategy for genetically improved seed must recognise the availability of existing seed production capacity that can be utilised to support the multiplication and distribution of genetically improved seed[27].

Figure 12 describes a tiered multiplication model that is frequently used for the multiplication and dissemination of improved germplasm across most livestock industries, including aquaculture[27].

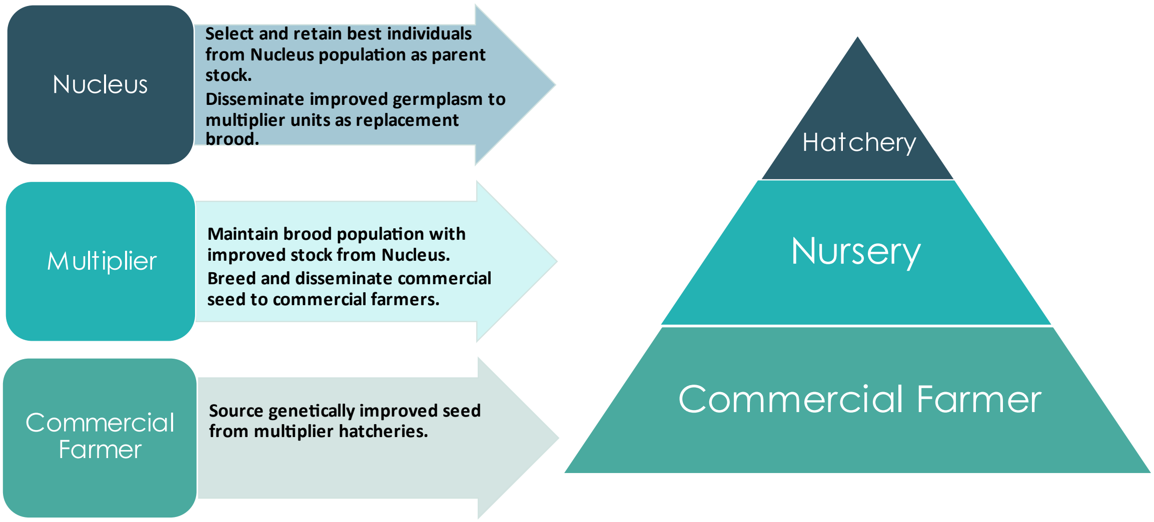


Figure 12: Potential structure of an industry genetic improvement program

The model relies on a central genetic improvement nucleus that provides a focal point for genetic improvement within the seed value chain. Through performance recording and genetic evaluation, the nucleus identifies elite genetics from within the nucleus population, selecting these as the parent stock for the next generation. The size of the nucleus is configured to ensure surplus seed germplasm can be disseminated as replacement broodstock to the multiplier hatcheries.

[27] R. W. Ponzoni, N. H. Nguyen, H. L. Khaw, and B. M. Rodriguez Jr. (2012) Considerations about effective dissemination of improved fish strains. WorldFish, Penang, Malaysia. Working Paper: 2012-47.

Existing private and government hatcheries can engage with the nucleus hatchery and act as multiplication hatcheries. Under this model the multipliers access replacement broodstock from the nucleus hatchery and use this to support the maintenance of a genetically improved brood population within their hatcheries. Seed produced within the multiplication hatcheries is subsequently sold to commercial grow out farmers[27].

The key advantages from this model comprise:

- Investments in genetic improvement can be focussed on the nucleus hatchery and scaled to match industry requirements. From a relatively small nucleus program it is possible to leverage a network of multiplication hatcheries to supply genetically improved seed to a large commercial industry.
- The model requires limited changes to existing operations of the multiplication hatcheries, supporting ease of adoption by key commercial partners.
- Partnering with a dispersed network of multiplication hatcheries can support more effective dissemination of improved seed across Zambia and greater accessibility for commercial farmers in more remote locations.
- The scope of the genetic improvement program can be expanded to other key aquaculture species without significant duplication of key resources. This will reduce potential investment if additional genetic improvement programs are developed in the future. A standalone genetic improvement nucleus is more conducive to the inclusion of additional species.
- The nucleus model is flexible and can support a number of ownership and partnership structures between the nucleus and the multipliers.

The GIP houses a Three Spotted Tilapia broodstock population of approximately 45,000 brood. It is estimated that the NARDC GIP could currently produce sufficient broodstock seed to sustain a network of multiplication hatcheries with the capacity to produce 22.5M commercial fingerlings per year (see later section for details of industry model). This level of fingerling production could sustain a commercial growing out industry producing 5,355t of output per annum.

Given current commercial production of approximately 2,000t, there is ample scope for the NARDC (when operated as a nucleus hatchery) to meet the demand for genetically improved seed from the commercial industry. Furthermore, it is understood that the Three Spotted Tilapia genetic improvement program only utilises 24 of the 80 ponds available at the NARDC, consequently there is scope to expand the program within the confines of the existing facility, if this is required to support higher levels of industry growth.

Potential Commercial Models for Seed Dissemination

Ownership and management of the nucleus program is discussed later in this report and is subject to potential financial returns/sustainability, management capacity and commercialisation strategy.

Irrespective of the ownership and management model (private versus Government), there are a number of models under which the nucleus hatchery can engage with a network of multiplier hatcheries[28], these models are described in Table 6 (below).

Table 6: Models for dissemination of improved germplasm

Model	Description
Direct Sale	The nucleus could sell genetically improved broodstock directly to the multiplier hatcheries.
Distribution Model	The nucleus owner could engage the multiplier hatcheries as distributors, producing and selling improved seed on behalf of the nucleus. The nucleus receives the revenue from subsequent seed sales but remits fees/commissions to the multiplier partners.
Vertical Integration	The nucleus owner could develop or acquire sufficient hatchery capacity to undertake multiplication within its own facilities.
Joint Venture	The nucleus owner and the multiplication hatcheries could pool their resources and expertise to establish a jointly owned business for the production and dissemination of improved seed. The partners would subsequently be remunerated via their shareholdings in the JV entity.
Strategic Alliance	The nucleus owner and the multiplication hatcheries could collaborate to share resources and expertise for the production and dissemination of improved seed, subsequently sharing the benefits of this collaboration amongst the partners.
Licensing	The nucleus provides broodstock to the multipliers under a license agreement and is remunerated via royalties that are levied on seed sales from the multipliers.
Franchising	Franchising represents a more enhanced form of licensing where the nucleus provides a broader scope of resources, systems, branding, IP and support to the multipliers.

Examples exist of all these models being applied to the dissemination of improved germplasm within the global aquaculture industry. However, licensing represents the most common model and is the most readily applicable for the dissemination of Three Spotted Tilapia within Zambia. Key advantages of licensing comprise the following:

- The model is suitable for generating revenue from commercial seed sales (via royalties). Due to the fecundity of Tilapia, the replacement broodstock market (in Zambia) is too small to generate sufficient revenue from a direct sale model.
- It is an easy model to establish, requiring less negotiation with partners relative to joint ventures, alliances and distribution models. Key commercial terms can be generic across partners and there is no requirement to negotiate ownership shares, profit-shares etc with partners.

[28] R. W. Ponzoni, N. H. Nguyen, H. L. Khaw, and B. M. Rodriguez Jr. (2012) Considerations about effective dissemination of improved fish strains. WorldFish, Penang, Malaysia. Working Paper: 2012-47.

- Licensing is easily scaled and promotes easier entry and exit of partners. There is no need to negotiate entry of new partners with existing partners. In addition, there is no direct need to consider overlapping territories or competition between licensees.
- The model is passive and allows the nucleus owner to focus on the operation of the nucleus hatchery without creating exposure to the operation of commercial hatcheries. Similarly, the model is easily implemented by the multiplier hatcheries, allowing these partners to retain commercial independence, supporting improved adoptability by these key partners.
- The model can be applied across a broader range of nucleus ownership models, particularly where ongoing public funding is required to support nucleus operations.

Figure 13 provides an overview of the potential structure of a licensing model for dissemination of improved broodstock to multiplier hatcheries. The key features of this model comprise:

- The execution of a license agreement between the nucleus hatchery (licensor) and the multiplier hatcheries (licensee). Broadly, the agreement describes the terms under which the licensor transfers broodstock to the licensee, and the permitted uses of the broodstock by the licensee.
- The negotiation of a royalty or license fee that is payable by the licensee for the use of the genetically improved broodstock. Royalties should be applied to commercial seed sales from the multiplier hatcheries to create the largest potential revenue base for the licensor and reduce the commercial risks to the licensee associated with fixed license fees.

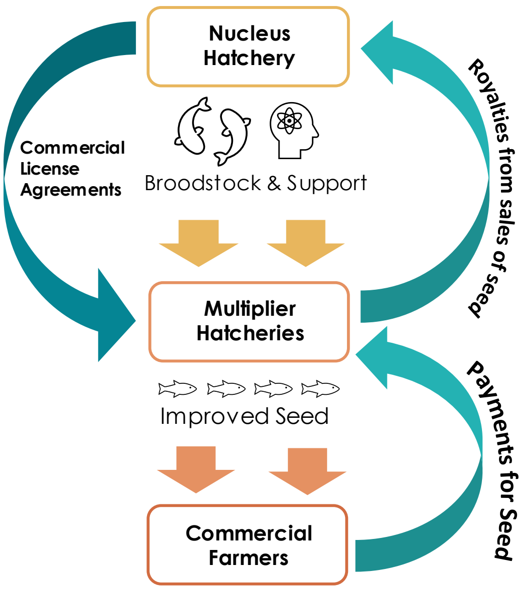


Figure 13: Potential structure of a broodstock license model

Based on the above, a licensing model has been adopted as the basis of subsequent financial forecasts within this report. This incorporates the application of a royalty on commercial seed sales as the primary mechanism for generating a revenue stream to support the operations of the nucleus breeding program.

Market Opportunity for Three Spotted Tilapia

A market assessment was undertaken to estimate the size of the potential market for Three Spotted Tilapia commercial fingerlings and multiplier broodstock in Zambia over the next 20 years. The projections, under low, medium, and high growth scenarios, form the basis of subsequent financial forecasts for the commercial viability of the genetic improvement nucleus (based on future industry demand for genetically improved seed).

Projections of future production of Three Spotted Tilapia were derived from forecasts of two key factors:

- The expected annual growth rate in overall aquaculture production in Zambia.
- The expected market share of Three Spotted Tilapia as a percentage of overall aquaculture production.

Given the current status of Three Spotted Tilapia production in Zambia indicates a small, immature industry, a range of three growth scenarios (high, medium and low growth) were developed to reflect uncertainty over the potential future growth trajectory. Forecasts were subsequently developed with reference to several key sources of market insight:

- Published literature and statistics on the current status of Zambian aquaculture and historical trends. Recent annual industry growth rates have averaged 8% (1995-2014), albeit from a low base level of production (see Figure 2).
- Stakeholder feedback from surveys and workshop discussions (see earlier summary).
- Comparative growth rates achieved over long timescales in other major developing country markets, particularly Bangladesh (7% compound annual growth rate over 2004 to 2019[29]) and Egypt (9% compound annual growth rate over 2000 to 2017[30]).

Based on this assessment the market growth forecasts assume a base level of industry growth consistent with long term growth rates in other major developing country aquaculture markets, adopting a 9% annual industry growth rate for the medium growth scenario. There is scope that the industry may continue to exceed this level of growth in the short term, however over a long term forecast it is inevitable that growth rates will slow as the industry expands.

A conservative level of market share was assumed for Three Spotted Tilapia, adopting a 15% market share under the medium growth forecast by Year 10. This reflects a slight increase on current market share of 10%, potentially due to displacement of other indigenous Tilapia species. The strong preference for Nile

[29] See: Bangladesh Department of Fisheries Annual Statistical Reports.
[30] See: General Authority for Fish Resources Development Statistical Yearbooks.

Tilapia among commercial farmers is likely to constrain the achievable market share of Three Spotted Tilapia, particularly as the commercial sector continues to drive industry growth.

Table 7 displays the subsequent industry growth rates and predicted market share for Three spotted Tilapia from 2022 to 2042 derived for the high, medium, and low growth scenarios. Currently Three Spotted Tilapia represents 10% of total aquaculture production. When estimating future output, it was assumed that the overall industry growth rate was constant and linear for the 20-year time horizon. Market share of Three Spotted Tilapia was expected to transition linearly from current market share to the nominated market share over 10 years, remaining fixed at that level for the final 10-year period of the forecast.

Table 7: Industry forecasts for low medium and high growth scenarios.

	Growth scenario		
	Low	**Medium**	**High**
Annual growth rate – aquaculture production	5%	9%	12%
Three Spotted Tilapia market share	5%	15%	25%
20-year CAGR - Three Spotted Tilapia	**4.6%**	**11.5%**	**17.5%**

Figure 14 presents corresponding forecasts of annual production of Three Spotted Tilapia utilising the growth scenarios presented above. Projections commence from 2023, coinciding with the earliest potential release of genetically improved seed from the multiplier hatcheries.

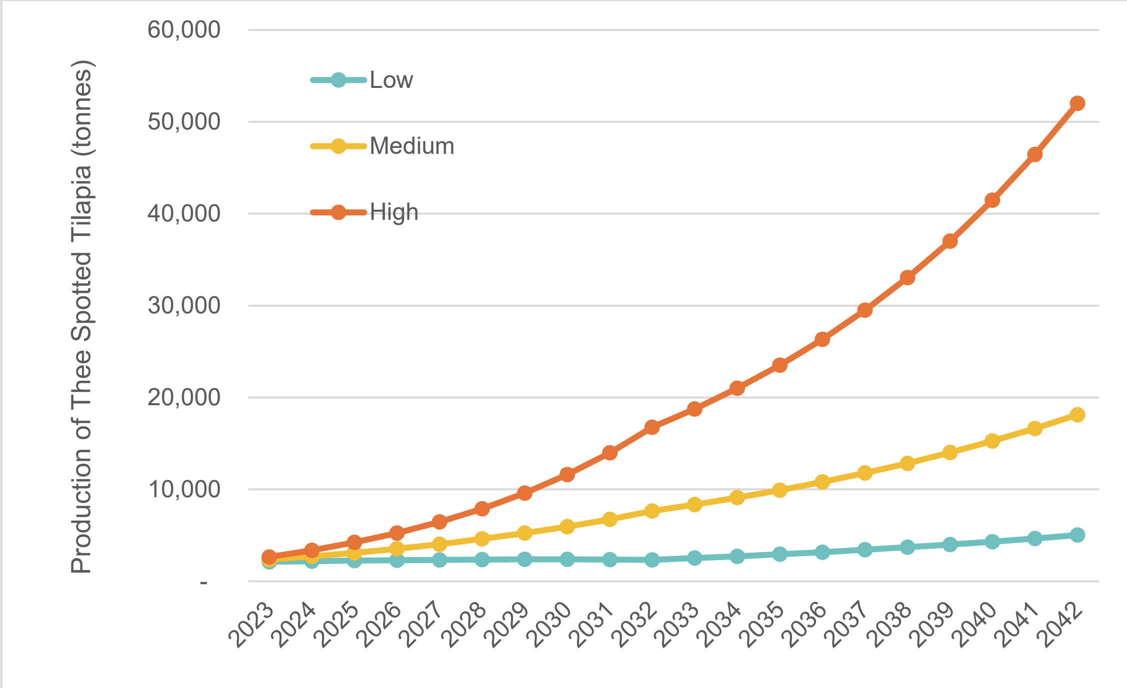


Figure 14: Forecast commercial production of Three Spotted Tilapia (tonnes)

These production forecasts form the basis of projections for future demand for Three Spotted Tilapia seed and broodstock requirements.

The ratio of fingerlings per tonne of commercial output was estimated from a model that incorporated the reproduction and survival parameters[31] described in Table 8. The analysis assumed an average weight per harvested fish of 350g.

Table 8: Survival rates to next stage and number required to produce 1 tonne of output.

Stage	Survival %	Number required per tonne of output
Market Fish	-	2,857
Fingerlings (2g)	68%	4,201
Fry (1g)	85%	4,943
Swim up Fry	85%	5,815
Yolk sac Fry	60%	9,692

A survival rate of 68% from 2g fingerling stage to finished fish weighing 350g implies that 1 tonne of harvested tilapia output requires 4,201 fingerlings as inputs (each weighing 2g). Applying this to the projections for industry growth presented in Figure

[31] Model parameters were reviewed by WorldFish.

14, estimates of future demand for fingerlings for the next 20 years were produced under high, medium, and low growth scenarios (Figure 15).

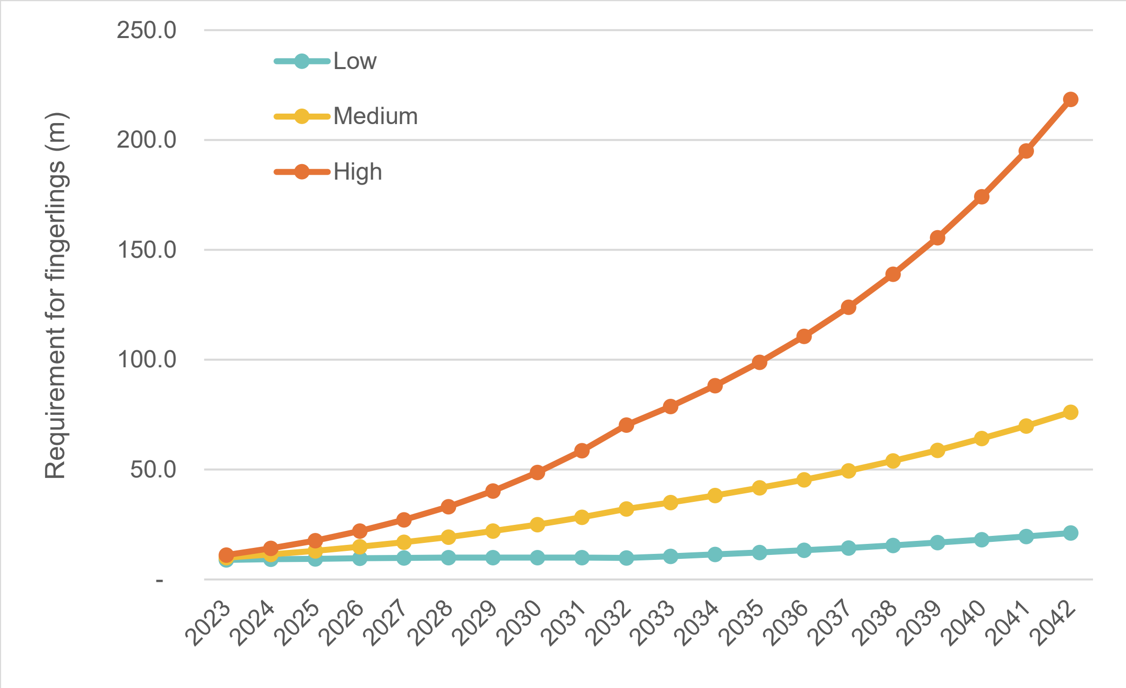


Figure 15: Forecast demand for Three Spotted Tilapia fingerlings (m)

Using projections of future levels of Three Spotted Tilapia production, combined with survival rates from yolk fry to harvest, future broodstock requirements were estimated. These forecasts are based on the following parameters:

- Estimated production of 200 yolk sac fry per female brood per month.
- A 1:1 male to female broodstock ratio within hatchery populations.
- A 50% annual turnover or replacement rate for broodstock populations (i.e., broodstock are kept for 2 years then replaced).

Based on the above, every 1 million fingerlings required at industry level was estimated to require a brood population of 1,922 mixed sex broodstock. Broodstock are kept on average for 2 years, therefore demand for replacement broodstock would be 961 broodstock per year (to produce 1 million commercial fingerlings). If demand for fingerlings is growing each year, then there is additional demand for broodstock to expand the number of fingerlings produced each year.

These projections of broodstock requirements are presented in Figure 16. These form the basis of financial forecasts of nucleus hatchery revenue and expenditure presented later in this report.

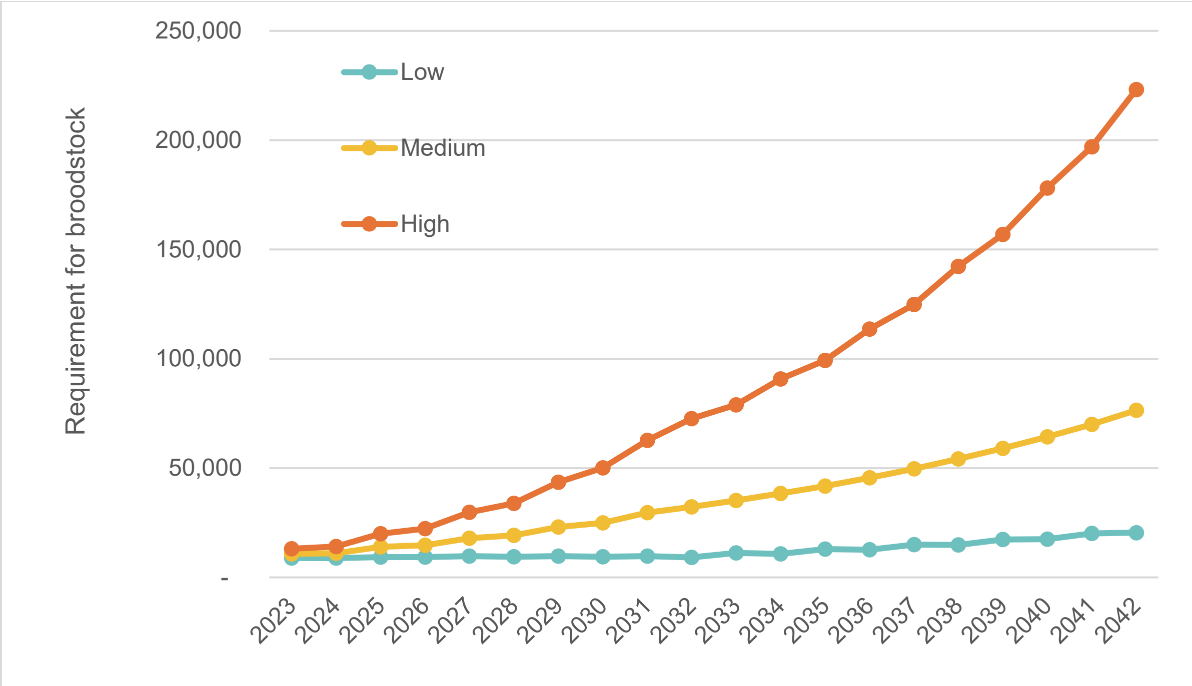


Figure 16: Forecast demand for Three Spotted Tilapia broodstock

These forecasts focus on potential demand within the Zambian aquaculture industry only. Three Spotted Tilapia is produced on a small scale in neighbouring countries, as well as other nearby countries such as Namibia. There is potential for the GIP to disseminate improved genetics more broadly than Zambia, however the current market potential is limited.

Potential Value of Improved Three Spotted Tilapia Seed

Current Zambian market prices for 2g Tilapia fingerlings range from ZMK0.5 to ZMK2 per fingerling[32]. Genetically improved seed has the potential to justify higher prices, reflecting the value added to end users (commercial farmers) from superior performance. An analysis was undertaken to estimate the potential value of genetically improved Three Spotted Tilapia to Zambian commercial farmers to help inform estimates of potential price premiums for genetically improved seed.

Future commercial release of genetically improved Three Spotted Tilapia could comprise the release of the first selected generation. It is estimated that well managed Tilapia breeding programs can generate genetic progress of 10% improvement in growth per generation[33]. Consequently, the initial commercial release could be expected to deliver growth performance advantages of up to 10% relative to unimproved strains (in suitable production environments). These advantages may be reduced in household systems due to genotype x environment effects associated with lower levels of nutrition and pond management – such that fish aren't given the opportunity to reach their full genetic potential.

[32] Personal communication, Rose Komugisha Basiita (CGIAR), 8/09/2021

[33] Tran et al (2020). Growth, yield and profitability of genetically improved farm tilapia (GIFT) and non-GIFT strains in Bangladesh. Unpublished – provided by John Benzie (WorldFish).

Table 9 utilises data collected from the farmer surveys described previously in this report and provides an estimation of the potential value to farmers of genetically improved Three Spotted Tilapia seed. The analysis incorporates the following inputs and assumptions:

- Harvest yield and revenue, and direct costs (seed, feed, and labour) were obtained from the farmer surveys described in Part 2.
- An estimated 10% increase in growth for first generation improved seed was adopted within commercial systems, and a lower yield gap of 7.5% within household systems.
- The analysis assumed all non-feed direct costs were not changed by the adoption of genetically improved seed. In addition, labour and other overhead costs were fixed and independent of adoption of improved seed.
- A constant feed conversion ratio (feed consumed per unit of output) was applied to both scenarios. This may not truly reflect the commercial reality where some improvement in feed conversion could be expected via improvement in growth rate. Instead, this approach was adopted due to a lack of data to support estimation of potential improvements in feed conversion and represents a conservative estimate.

Table 9: Estimation of Impact on Farm Profitability from Genetically Improved Seed

	Large scale commercial		Small scale pond	
	Unimproved Seed	Improved Seed	Unimproved Seed	Improved Seed
Fingerlings stocked (per Hectare)	34,900	34,900	28,611	28,611
Percentage of output sold (Table size)	100%		89%	
Cycle Revenue per Hectare ($ZMK)	446,715	491,387	272,759	293,216
Seed cost ($ZMK per Hectare)	27,920	27,920	9,798	9,798
Feed cost ($ZMK per Hectare)	64,215	70,637	32,576	35,020
Labour cost ($ZMK per Hectare)	1,954	1,954	35,104	35,104
Other costs ($ZMK per Hectare)	489	489	8,005	8,005
Farm Margin ($ZMK per Hectare)	352,137	390,387	187,276	205,289
Added Margin - Improved Seed	**-**	**38,250**	**-**	**18,014**
Added Margin per Fingerling	**-**	**1.10**	**-**	**0.63**

Relative to current market pricing for generic Tilapia fingerlings, the potential additional value of genetically improved Three Spotted Tilapia seed appears to be significant (at ZMK 0.63 to 1.1 per fingerling) (Table 9). The analysis also demonstrates the potential for improved seed to deliver increased benefit per fingerling within more intensively managed systems, such as cage culture systems. To forecast potential royalty revenue, it was assumed that the nucleus operator would adopt pricing reflecting expected value across lower-intensity systems, accepting this foregoes potential value within more intensive systems but will support adoption by household farmers.

On this basis, genetically improved Three Spotted Tilapia seed was estimated to have a commercial value of ZMK 0.6 per fingerling above unimproved fingerlings currently utilised within Zambian aquaculture. This reflects the potential value of the first selected generation. Subsequent releases of new selected generations will generate greater farm-level impact as genetic improvement is both permanent and cumulative. The greater value of subsequent generations can support increased royalty rates as new generations are released.

To support adoption of genetically improved seed, adopting farmers need to retain a large proportion of the value created by the genetically improved seed. Farmers are often risk averse and may require a larger incentive to overcome uncertainty of the visibility and realisability of benefits.

Based on the results from Table 9, it is estimated that farmers could pay up to 0.63 per fingerling and achieve the same level of profit as currently achieved with unimproved strains.

On this basis, a residual value of ZMK 0.3 (i.e., 50% of the yield gap value) per fingerling could be shared between the nucleus hatchery and its licenced multiplier hatcheries, with the remaining 50% captured by adopting farmers. Consequently, a royalty value of ZMK 0.15 per 2g fingerling has been assumed for the initial commercial release of genetically improved Three Spotted Tilapia seed. This would represent the nucleus operator’s expected licensing revenue from sales of fingerlings via multiplication hatcheries.
As previously described, royalties should be revised following the release of new generations, particularly as new traits are developed and integrated into the breeding program.

The analysis underpinning this estimate must be reviewed both during subsequent phases of implementation and following collection of in-market performance evaluation data for genetically improved Three Spotted Tilapia seed (yield gap data). This should also be informed by consultation with both partner hatcheries and commercial and smallholder producers.

Outlook for the Commercial Sustainability of a Three Spotted Tilapia Breeding Program

To assess the viability of a nucleus hatchery supplying genetically enhanced broodstock to commercial multipliers (who sell fingerlings to commercial farms) the revenues and costs for a nucleus hatchery with initial capacity to produce 45,000 broodstock per year were estimated.

Annual revenue and costs were modelled over 20 years (commencing in 2023), under the high, medium, and low industry growth scenarios described previously.

Revenue for the nucleus hatchery was generated via seed royalties, paid by the multiplier hatcheries in accordance with their forecast seed sales. Royalty revenue was assumed to be derived from a 75% market-share of the commercial fingerling market (under high, medium, and low growth scenarios) predicted in Figure 16. The base level of market-share reflected expected high adoption of genetically improved seed among the existing Three Spotted Tilapia commercial sector, offset by lower penetration among household farmers where accessibility and cost could affect adoption.

Operating costs for the nucleus hatchery were derived from the current NARDC GIP and split into 3 categories: capital, operating, and feed costs. A summary of the base cost structure for the nucleus hatchery are presented in Table 10 below (based on the existing NARDC hatchery).

Table 10: Capital, operating, and feed costs for a hatchery with 45,000 capacity[34].

	Total cost (ZMK)	Per broodstock (ZMK)
Capital costs (one-off expenses)	**2,965,350**	**65.9**
Operating costs		
Staff salaries	*1,570,800*	*34.9*
Pump and hatchery maintenance	*276,000*	*6.1*
Feed cost	**1,701,274**	**37.8**
Total annual operating costs	**3,548,074**	**144.7**

Capital costs represent one-off expenditure, for buildings and equipment required to house and grow broodstock (e.g., tanks, ponds). The NARDC currently houses 45,000 Three Spotted Tilapia broodstock, as the number of nucleus broodstock required to meet industry demand exceeded 45,000, a one-off capital expense was included in annual hatchery costs to cover the increase in capacity.

Operating costs are fixed expenses, covering maintenance and staff salaries to operate the hatchery. When hatchery capacity is less than 45,000, these remain constant each year, however, when the number of broodstock produced is projected to exceed 45,000, operating expenses are scaled according to the increase in broodstock capacity. Feed costs were calculated based on the projected number of broodstock produced in a given year.

As previously described, revenue was based on an initial royalty of ZMK 0.15 per fingerling sold under license from the multiplier hatcheries.

[34] Source: Estimates derived from indicative GIP operational expenses at USD exchange rate of 18ZMK: 1USD, 8/09/2021

The initial royalty is based on estimates of the value of the current first selected generation of genetically improved Three Spotted Tilapia. Given that genetic progress is cumulative, royalties could be increased for subsequent generations as the value of improved seed compounds. Further royalty increases could also be justified by the inclusion of new traits within the nucleus breeding program that enhance the value to commercial farmers, and via faster genetic progress through the adoption of genomics and other program enhancements.

Current rates of annual inflation in Zambia are very high, associated with the impacts of COVID-19 on the economy and the Kwacha. However, annual inflation had sat within the range of 6-10% per annum between 2010-2019[35]. These rates of annual cost inflation are broadly consistent with expected rates of genetic progress within the nucleus breeding program. On this basis, forecasts of future revenue and cost were projected in real 2021 values and for simplicity it was assumed that cost and price inflation were equivalent.

Figure 17 displays the forecast of annual profit/loss for the nucleus hatchery reflecting the methodology and assumptions described above. Forecasts are presented for the high, medium and low industry growth scenarios and their resultant estimates of fingerling market size.

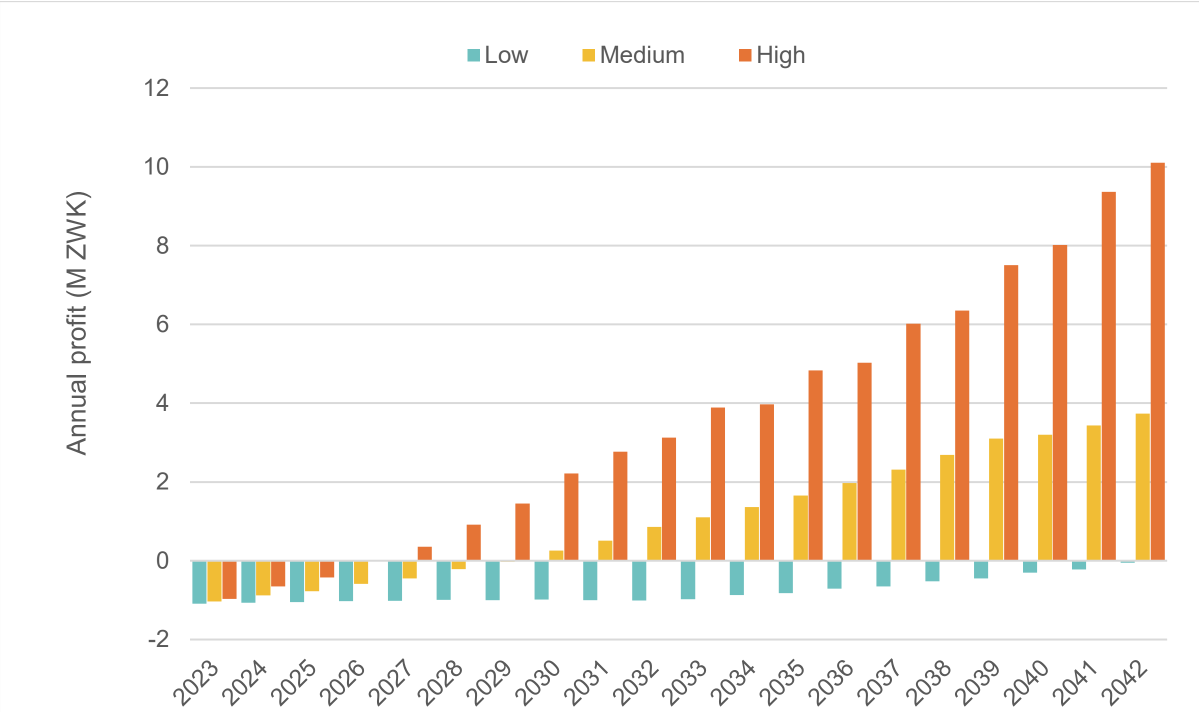


Figure 17: Hatchery profit/loss for next 20 years under high, medium, and low growth scenarios.

These results highlight a potential breakeven industry size of approximately 5,500 t of commercial Three Spotted Tilapia production. This corresponds to an expected

[35] See: https://data.worldbank.org/indicator/FP.CPI.TOTL.ZG?end=2020&locations=ZM&start=1986&view=chart

annual fingerling market of approximately 22M fingerlings. This breakeven point is approximately 2.5 times the size of the current industry.

Table 11 presents a summary of nucleus hatchery profit and loss under each market growth scenario. A real discount rate of 7% was applied for calculating annualised profit forecasts.

Table 11: Hatchery performance indicators under high, medium, and low growth scenarios (where royalty per fingerling = 0.15 ZMK and market share = 75%)

	Growth scenario		
	Low	Medium	High
Years until break even	na	8	5
Average Fingerling sales/year in first 10 years	7.25M	14.48M	25.74M
Annualised PV of 10 years operations (m ZWK)[1]	-1.03	-0.35	0.62
Annualised PV of 20 years operations (m ZWK)[1]	-0.89	0.54	2.47

[1] Annualised PV corresponds to the average annual profit/loss in present value terms.

These results highlight the nucleus hatchery has the potential to operate profitably in the longer-term, particularly if longer-term industry growth rates can exceed 10% per annum.

The forecasts do not include costs associated with the provision of any external technical support to the nucleus breeding program. Currently the breeding program is supported by WorldFish via the ZAEDP project. Ongoing technical support could reflect an additional cost that may impact the profitability forecasts presented above. To provide some perspective on these potential impacts, USD$150K of ongoing technical support would render all scenarios bar the high growth scenario unprofitable.

To further assess the potential commercial viability of the nucleus hatchery, a sensitivity analysis was undertaken to test sensitivity to market-share and royalty parameters. Results of the sensitivity analysis are presented in Table 12 (market-share) and Table 13 (royalty) respectively.

Table 12: Sensitivity of hatchery performance indicators to market share.

	Growth scenario		
	Low	Medium	High
Market share = 10%			
Years until break even	na	na	18
Annualised PV of 10 years operations (m ZWK)	-1.74	-1.65	-1.51
Annualised PV of 20 years operations (m ZWK)	-1.72	-1.52	-1.13

Market share = 25%			
Years until break even	na	19	10
Annualised PV of 10 years operations (m ZWK)	-1.57	-1.35	-1.00
Annualised PV of 20 years operations (m ZWK)	-1.53	-1.04	-0.10
Market share = 50%			
Years until break even	na	11	7
Annualised PV of 10 years operations (m ZWK)	-1.30	-0.85	-0.15
Annualised PV of 20 years operations (m ZWK)	-1.21	-0.22	1.29
Market share = 75% (baseline scenario)			
Years until break even	na	8	5
Annualised PV of 10 years operations (m ZWK)	-1.03	-0.35	0.62
Annualised PV of 20 years operations (m ZWK)	-0.89	0.54	2.47
Market share = 90%			
Years until break even	18	6	4
Annualised PV of 10 years operations (m ZWK)	-0.87	-0.05	1.01
Annualised PV of 20 years operations (m ZWK)	-0.70	0.96	3.14

Table 13: Sensitivity of hatchery performance indicators to royalty per fingerling.

	Growth scenario		
	Low	Medium	High
Royalty = 0.05 ZWK			
Years until break even	na	na	na
Annualised PV of 10 years operations (m ZWK)	-1.75	-1.70	-1.70
Annualised PV of 20 years operations (m ZWK)	-1.74	-1.64	-2.34
Royalty = 0.10 ZWK			
Years until break even	na	13	8
Annualised PV of 10 years operations (m ZWK)	-1.39	-1.02	-0.54
Annualised PV of 20 years operations (m ZWK)	-1.31	-0.55	0.06
Royalty = 0.15 ZWK (baseline scenario)			
Years until break even	na	8	5
Annualised PV of 10 years operations (m ZWK)	-1.03	-0.35	0.62
Annualised PV of 20 years operations (m ZWK)	-0.89	0.54	2.47
Royalty = 0.20 ZWK			

Years until break even	16	5	3
Annualised PV of 10 years operations (m ZWK)	-0.67	0.33	1.77
Annualised PV of 20 years operations (m ZWK)	-0.46	1.63	4.88
Royalty = 0.25 ZWK			
Years until break even	13	3	2
Annualised PV of 10 years operations (m ZWK)	-0.31	1.00	2.93
Annualised PV of 20 years operations (m ZWK)	-0.04	2.72	7.29

Implications for Ongoing Ownership & Management

Critical to the success of the GIP is the ongoing genetic improvement of the brood population. Ongoing genetic improvement has the potential to deliver greater industry impact via the cumulative benefits of genetic progress and support greater industry adoption. This continuity requires a model for ongoing ownership/management of the GIP that is commercially realistic, and likely to ensure accessibility to the necessary expertise.

Table 14 describes potential models for ownership and operation of the GIP (either at NARDC or a private facility).

Table 14 Potential GIP ownership and operation models

Owner/Operator	Description of Model	Strengths & Weaknesses
Government owned and operated	Government remains the sole owner and operator of the facility, utilising its own facilities and personnel for management of GIP operations.	✓ Government can ensure open access to improved genetics. ✓ Government can more readily access funds to support hatchery operations. ✓ Public control maintained over GIP germplasm. ✓ Easier to provide low-cost fingerlings to smallholder farmers. × Unprofitable operations can become a burden on public finances. × Government may require ongoing technical and commercial support for successful management of the GIP. × Ongoing commitment to the GIP relies on continuing political and ministerial support.
Government owned and commercially operated	Government could retain ownership of the germplasm and provide access to a private operator to manage the breeding program and disseminate genetics to industry. This could occur through a lease of the relevant NARDC facilities or enabling transfer to private facilities. The private party could be engaged	✓ Public interest is retained in the GIP to support continuity. ✓ Reduces reliance on Government for technical and commercial management of GIP. ✓ Reduces Government's exposure to potential revenue shortfalls. ✓ Government can use agreements to set performance requirements for commercial partner/s. × Model creates operational and partner risks for Government.

Owner/Operator	Description of Model	Strengths & Weaknesses
	via a germplasm lease or licence or could be contracted to manage the program on the Government's behalf.	× Model can disincentivise commercial investment in GIP due to lack of ownership. × Commercial interest subject to apparent stability and commitment of Government. × Less scope to support public-good activities such as provision of low-cost fingerlings.
Commercially owned and operated	The Government could privatise the GIP via a commercial tender, transferring the GIP germplasm to a commercial party to assume ownership and management of the GIP. It is possible that the tender process could encourage joint ventures between commercial parties to support broader accessibility. It may also be possible for the Government to retain a small backup population and first right to repurchase as a means of protecting the continuity of the GIP.	✓ No reliance on Government for technical and commercial management of GIP. ✓ Frees up Government resources for alternate investment and deployment. ✓ No Government exposure to potential revenue shortfalls. × Commercial operation may target dissemination only where commercially viable. × No public interest retained to ensure continuity of GIP.
Public-Private Joint Venture	The Government and private sector could create a joint venture to own and manage the GIP. The JV is established as a separate entity to its partners, with partners retaining shareholdings. Profits from the JV are distributed to partners in accordance with their shareholdings.	✓ Public interest is retained in the GIP to support continuity. ✓ Reduces reliance on Government for technical and commercial management of GIP. ✓ Frees up Government resources for alternate investment and deployment. ✓ No Government exposure to potential revenue shortfalls. × Complex to negotiate and establish. × Requires good relationships among partners to function effectively – politically very challenging. × Once established, can be inflexible and difficult to unwind or exit.

During stakeholder workshops, Industry stakeholders expressed a preference for a model that included private sector ownership/operation and continued support from experienced technical organisations in the operation of the Three Spotted Tilapia GIP. It was perceived that this would support:

- Efficient management of the GIP,
- Maintenance of good industry relationships and connectedness, and
- Commitment to ongoing genetic improvement that is aligned to industry needs.

The financial forecasts highlight that the Three Spotted Tilapia GIP at NARDC is not likely to be commercially profitable for at least 5 years from commencement of dissemination. This reflects the small current scale of the commercial industry and subsequently low initial revenue base. Whilst 5 years to a point of breakeven is not insurmountable for a private investor, it must be recognised that:

- This reflects the expected timeframe under the most aggressive industry growth scenario, with the transition taking 8 years under the medium growth forecast and upwards of 20 years for the low growth scenario. This timeframe is too long for an investor seeking a commercial return on their investment.
- The expected timeframes are best cases and do not account for additional costs associated with potential access to third party technical expertise which could further reduce viability.
- The genetically improved Three Spotted Tilapia is yet to undergo commercial performance evaluation to benchmark against unimproved strains and alternate species (including Nile Tilapia). There is short to medium term uncertainty about the performance of the improved seed and subsequent demand.

Based on the above, it is unlikely that the Three Spotted Tilapia GIP could continue without some level of ongoing Government or donor support until it can reach a point of commercial viability. Based on the financial forecasts, this level of cumulative transitionary support could range between ZMK 2M (high growth scenario), up to ZMK 16M (low growth scenario) in real 2021 values.

Consequently, the Zambian Government must consider its own objectives for continuation of the GIP and its capacity to meet the potential funding shortfalls forecast within this report. Subject to the above, engagement can proceed with the commercial sector to understand commercial sector views on collaboration and co-investment into the GIP, and potential models that could support their interest.

During the stakeholder workshops, several commercial stakeholders expressed interest in partnering or supporting the GIP, consequently there is potential commercial sector interest in the GIP. Ultimately this can only be engaged/explored once the Government has identified its appetite and capacity to continue to support the GIP, and the terms under which it may want to engage with the commercial sector.

In addition, the Government should also consider the scale of investment that is required to support the Three Spotted Tilapia GIP and consider this alongside alternate uses of resources. Key considerations associated with the continuation of the GIP and its potential return on investment comprise the following:

- Access to improved seed has been identified by stakeholders as one of a series of constraints that impact the aquaculture industry. There is risk that industry growth may continue to be constrained despite the provision of improved seed unless a holistic approach to industry development is adopted.
- Investment in genetic improvement produces benefits that accrue and compound over long time horizons. Strategies and investments that address other constraints such as access to feed, access to finance and lack of technical support/expertise may deliver greater industry benefits, particularly in the short-term.
- There is a lack of performance evaluation data comparing Three Spotted Tilapia against genetically improved strains of Nile Tilapia. Availability of this

data would better inform the cost-benefit and risk assessments associated with continuing the GIP, particularly if the current distribution of Nile Tilapia is reassessed.

- There is a need to consider the availability of the required technical expertise to support the ongoing management of the GIP. Long-term benefits from the GIP require ongoing genetic improvement, as well as the sustainable management of the brood population. The expertise to achieve this may require ongoing support from an appropriate research for development organisation. Funding of this support will also require consideration as a potential additional outgoing alongside the investment commitments identified in this report.

Key Findings & Recommendations

Table 15 summarises the key findings from the assessment of the commercial sustainability of the Three Spotted Tilapia GIP.

Table 15 Summary of key findings

Topic	Key Findings
Market opportunity for genetically improved Three Spotted Tilapia	• Three Spotted Tilapia is the second largest contributor to aquaculture output in Zambia, responsible for approximately 10% of current production. • The species is most commonly produced within commercial systems and fills an important niche in regions where the cultivation of Nile Tilapia is not permitted. • Industry growth outside the Southern province is constrained by a variety of factors including, cost and availability of processed feeds, access to major urban markets, and lack of technical expertise and support. • To assess the potential demand for genetically improved fingerlings, a range of market growth forecasts were developed. The base, medium growth forecast incorporated an annual growth rate of 11.5% over 20 years. This is broadly consistent with current growth rates, and growth achieved in other major developing country aquaculture sectors. • Under the medium growth forecast, production of Three Spotted Tilapia was forecast to increase to 18,000 t by Y20, with subsequent fingerling demand of 76M fingerlings.
Models for disseminating genetically improved fingerlings to commercial farmers	• Current Three Spotted Tilapia production is supported by a network of hatcheries that are mostly privately owned. This provides an opportunity to scale-up and multiply output from the GIP. • The most efficient model for disseminating genetically improved fingerlings is for the GIP to operate as a genetic improvement nucleus, disseminating broodstock fingerlings to existing (and new hatcheries) that operate as multiplier units. • A licensing model could be adopted to support the transfer of broodstock to the multiplier units. This would incorporate the application of a royalty on sales of commercial fingerlings from the multiplier units as the key revenue stream to support the GIP. • Estimates of the potential on-farm value of genetically improved Three Spotted Tilapia indicate a potential royalty of ZMK 0.15 per fingerling could be applied to the release of the first generation.
Commercial sustainability of the Three Spotted Tilapia GIP	• Utilising the royalty forecasts and market growth projections, a model was developed to forecast the annual profit and loss of the GIP over 20 years (from 2023).

	• Under medium to higher growth forecasts the GIP could become self- sustaining within 5-8 years. This reflected the small current market size and the need for this to grow to a level (approx. 5,500t) that could support the GIP. • Consequently, there is a need for ongoing Government or donor support to maintain the GIP until it can reach a point of commercial sustainability. Indicative support could reach ZMK 16M over 20 years (real 2021 value). • Greater financial support may be required if there is a need for ongoing technical support from relevant research for development organisation or private consultancy provider. • Potential involvement of the commercial sector in the GIP could be pursued but it is unlikely that the GIP could operate on a commercial basis for several years. • The Government needs to clarify its objectives and capacity to support the GIP before engaging further with the commercial sector. A cost-benefit analysis should also be undertaken to support potential investment decisions.

Based on the above, a series of recommendations (Table 16) have been proposed to progress Government and industry decision making over the continuation of the Three Spotted Tilapia GIP.

Table 16 Recommendations

Recommendation	Description
Recommendation 1 Performance evaluation and benchmarking	There is a lack of objective data comparing the performance of Three Spotted Tilapia and Nile Tilapia (commercial, genetically improved strains). In addition, there is also a need to validate the expected performance advantages of genetically improved Three Spotted Tilapia versus unimproved strains. These insights are critical for supporting adoption of improved seed and informing pricing/royalty decisions. **There is an urgent need to undertake rigorous performance evaluation and benchmarking of Three Spotted Tilapia to increase farmer awareness and adoption, and better inform policy decisions.**
Recommendation 2 Species distribution assessments and policy review	In concert with Recommendation 1, there is a need to collect robust data on the distribution of Tilapia species across Zambia to better inform application of existing biodiversity policies and support investment decisions around the genetic improvement of indigenous species. Stakeholders express a clear preference for Nile Tilapia, indicating there is significant risk to committing to continuation of the GIP without an up to date understanding of the validity of current restrictions on the use of Nile Tilapia. **There is a need to undertake further wild population surveys of Tilapia distribution to better inform application of biodiversity policies that restrict aquaculture use of key species. In addition, there is an urgent need for mapping resources to clarify the current application of these policies.**
Recommendation 3 Technical capacity & support	To inform Government decisions around the ongoing ownership and management of the GIP, and appetite to meet the investment required to sustain the GIP, there is a need to consider the availability of technical expertise to support the GIP. This should include engagement with relevant research for development organisations to explore options and models for the provision of ongoing technical support to the GIP. Identification of applicable costs and potential funding options is also required to identify impacts on GIP investment requirements and commercial sustainability. **There is an urgent need to consider the requirements for ongoing technical support to the GIP and its implications for investment requirements and commercial sustainability.**
Recommendation 4	Stakeholders have identified a number of inter-related barriers that will affect the growth and development of the Zambian aquaculture industry, particularly outside the Southern province. Whilst the availability of genetically improved fingerlings for Three Spotted

Cost-benefit analysis and investment strategy	Tilapia is considered beneficial for industry development, **there is a need for a broader cost-benefit analysis across genetically improved seed and other potential industry support interventions to help inform prioritisation of Government investment and resource deployment.**
Recommendation 5 Industry consultation to finalise GIP strategy	Subject to the outcomes from Recommendations 1 to 4, Government needs to develop a strategy for continuation of the GIP that includes a clear position on potential ongoing Government support, and preferred ownership/operations models. This can be informed by the recommended model outlined in this report as a basis for consultation. **Government must identify its capacity to continue the GIP and its strategic objectives for continuation of the program. Subject to the above, Government can then engage with the commercial sector to identify the preferred model for ownership and management of the GIP, and appetite for commercial investment/partnership. This can then inform the roll-out of a process to engage with commercial investors/partners, and secure funding/resources for continuation of the GIP.**
Recommendation 6 GIP governance	Irrespective of the outcomes of Recommendations 3 and 5, and the model adopted for ownership and management of the GIP, the ongoing management of the GIP would benefit from a governance structure that includes ongoing participation from industry and technical personnel via a governance/advisory Board or committee. This mechanism can ensure greater alignment between GIP operations and industry needs, and provide appropriate technical oversight over the GIP. **Subject to continuation of the GIP, an advisory Board or committee should be established to support greater transparency, industry alignment and technical rigour within the GIP. This board should include representation from industry stakeholders and appropriate technical experts.**

6. Data and Information Systems to Support the Hatchery Sector

Data and Information Needs for Hatchery Operators

This section of the report seeks to identify appropriate industry monitoring systems, data requirements and applicable standards/protocols to support the operations and management of the hatchery sector, particularly the genetic improvement nucleus. This will comprise identification of the key data and information needs of the sector, which, when fulfilled, will further support the supply of quality seed that aligns with industry needs.

There are a number of layers of data requirements to support a national breeding programme for Three Spotted Tilapia in Zambia as well as the broader hatchery sector. These data requirements can be described in the context of the key technical and operational requirements for successful hatchery operations and associated genetic improvement programmes, these requirements comprise:

- Development of a phenotypic and genotypic data collection program to support the development of a genetic evaluation that will enable the identification and selection of genetically superior broodstock. The genetic evaluation supports the generation of genetic progress within the breeding program.
- Maintaining the health and productivity of the brood population through appropriate nutrition, biosecurity, and aquatic health practices, as well as maintenance of genetic diversity to manage inbreeding risks.
- Marketing and dissemination of genetically improved germplasm to industry customers to generate revenue that supports hatchery operations and the broader genetic improvement program.

Generally, data collected at the grow-out farm level is only applicable to the latter two requirements (maintaining health and productivity of the brood population, and marketing and dissemination of improved germplasm).

From a genetic improvement perspective, hatchery operators need to be able to collect standardised phenotypic and genotypic data from within well-defined contemporary groups to support development of genetic evaluations. There are significant challenges associated with using commercial grow-out farm data as a source of phenotypic records for genetic evaluation, these challenges comprise:

- Maintaining genetically linked and well-defined contemporary groups across commercial farms is essential for ensuring observed differences in performance are mostly due to genetic factors and not environmental factors. This is difficult to achieve at the farm level due to vast differences in pond/cage environments, management and data collection and recording practices among grow-out farmers.

- Farm data needs to be able to be linked back to individuals or families within the nucleus population to inform the genetic evaluation of the nucleus. It is difficult to record and maintain pedigrees within grow-out systems, whilst the use of genotyping can be cost prohibitive.

As a result, collection of phenotypic and genotypic data is best managed within the nucleus breeding program where appropriate performance evaluation programs can be more easily implemented and managed with the required rigour. Commercial evaluations and progeny tests are best undertaken on a small, targeted basis to complement nucleus performance recording programs.

As a result, potential applications for data collected from industry statistics and market data is mostly used to inform commercial operations and more basic genetic improvement applications within hatchery breeding programs. For example, information on the number of commercial farmers and their seed requirements are needed to optimise the scale and structure of the nucleus program, as well as providing information on the potential market opportunity, market segments and logistics associated with distribution of product within the supply chain.

Figure 18 provides a summary of the potential genetic improvement applications and commercial applications (within a genetic improvement nucleus) of the industry datasets that are typically collected at a national level. For simplicity, these applications have been classified as follows:

- Supporting commercial operations e.g., via the use of market and industry data to inform pricing decisions and identify target markets to ensure that profit can be optimised.
- Supporting genetic improvement of the population e.g., via the identification of key commercial traits for implementation within the breeding program.

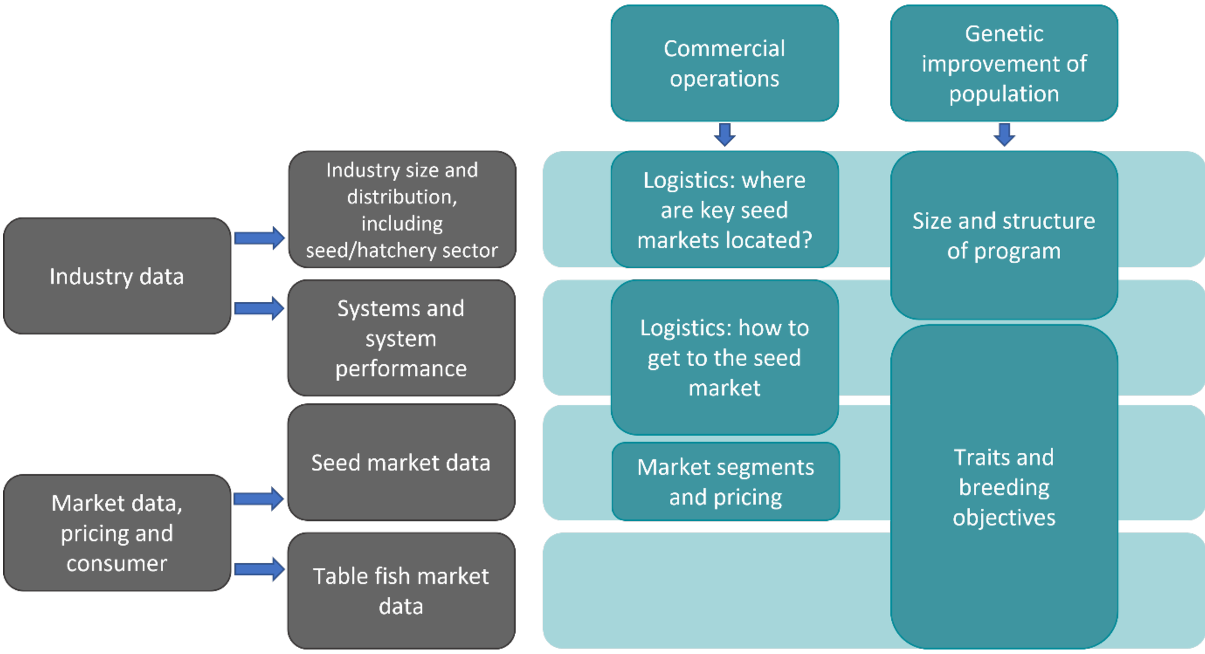


Figure 18 Potential applications of industry datasets within nucleus hatchery breeding programs

As per Figure 18 the priority datasets that support commercial functions within hatcheries comprise the following:

- **Industry level data**: predominately comprising basic industry statistics that incorporate the size, structure (e.g. types of production systems and their level of performance) and distribution of the industry. This provides insights into the size of the potential market and accessible market segments (based on regional and commercial factors). Knowing how much seed is required by industry will allow hatcheries to make commercial decisions around how much seed to produce, where to sell seed and how to price it. Knowledge of the industry structure (e.g. commercial versus household production) is important, helping inform market assessments based on expected demand within key segments.
- **Farm level data**: predominately comprising data describing the profitability and productivity of major farm systems, as well their key inputs (e.g. fingerling requirements and feed costs) and outputs (fish yields and prices) helps further inform assessments on market demand for seed. This data can also provide insights on seed pricing and farmer capacity to pay a price premium for genetically improved fingerlings.
- **Hatchery and seed/fingerling statistics:** predominately comprising data describing hatchery numbers, fingerling production (by species) and fingerling prices supports market and pricing assessments and market entry strategies, particularly partnership strategies with commercial multiplier hatcheries.

In addition to the above, Figure 18 also identifies important genetic improvement opportunities associated with these key datasets. These opportunities comprise the following:

- **Industry level data**: predominately comprising basic industry statistics that incorporate the size, structure (e.g. types of production systems and their level of performance) and distribution of the industry. As previously described this data helps inform market assessments which shape the potential broodstock and fingerling production from the hatchery sector. These production forecasts are vital for determining the optimal size and structure of the breeding program to ensure it can meet industry requirements. Industry trends are important as brood populations may take several years to adjust in response to shifts in market demand.
- **Farm level data**: predominately comprising data describing the profitability and productivity of major farm systems, as well their key inputs (e.g. fingerling requirements and feed costs) and outputs (fish yields and prices) helps inform industry needs regarding the development of new breeding traits within the genetic evaluation for the nucleus hatchery. In addition, as the genetic evaluation evolves into multi-trait selection, farm system data is vital for development of breeding objectives and selection indexes that weight traits according to their impact on commercial profit. A well-designed breeding program is closely aligned to the needs and profit drivers of the commercial sector to ensure that genetic progress within the breeding program is delivering commercial benefit to end users.
- **Market data and statistics:** comprising data describing the value chain for harvested fish, including fish pricing (by species, weight, region, market channel etc), import/export volumes and description of key market channels also ties in with farm level data to help inform the development of traits associated to improve the yield and quality of harvested fish. This also helps ensure genetic progress can support market and consumer requirements.

In addition to these data sources, the hatchery sector also requires standards or specifications for seed/fingerlings to underpin seed quality and support greater price transparency. Standards and specifications are not specifically an industry dataset such as the information sources described above, however they contribute to improved data quality and transparency within the primary data systems.

Current Industry Data Systems and Data Availability

Based on the above this assessment has identified the core components of an industry data system to support the hatchery sector. These data requirements comprise the provision of quality industry level statistics, farm-level data, hatchery and seed sector data, and market data. The current availability of these datasets for the Zambian Aquaculture industry is assessed in Table 17 and Table 18.

Table 17 Current Zambian industry aquaculture datasets

Data Source	Description & Methodology
Ministry of Livestock & Fisheries Census	• Periodic census survey of the livestock and fisheries/aquaculture sector. • Most recent census was 2018, previously 1992 and 1971. • Methodology is sample-based and imputed up to a national level. • Aquaculture data comprises:

	○ Fish production by species across household and commercial systems. ○ Fish production by province. ○ Farm system types (ponds versus cages). ○ Type of fish produced (table size versus fingerlings).
Department of Fisheries Annual Report	• Annual report that collects and reports statistics on fisheries and aquaculture production and activity. • Methodology is sample-based and imputed up to a national level. • Aquaculture data comprises: ○ Fish production across household and commercial systems. ○ Fish production by province. ○ Farm system types (ponds versus cages). ○ Basic farm statistics e.g. farm sizes, yields ○ Seed prices (non-species specific). ○ Market fish prices by point of sale (non-species specific). ○ Also reports industry developmental activity by the Department.
Periodic Research Surveys	• Numerous research studies have been undertaken across the fisheries and aquaculture sector, these studies have included the collection and reporting of industry data and statistics, farm-level data, market and value chain data. • Studies tend to be isolated (one-off) and focused on specific topical issues. • Examples include Nsonga (2015)[36] and Simataa and Musuka (2013)[37]

Table 18 Completeness of existing industry datasets

Data Source	Completeness & Suitability
Ministry of Livestock & Fisheries Census	• Good scope of data collection. Only source reporting the species composition of aquaculture production. • Census is undertaken too infrequently to support identification of major trends. • The sample-based approach is potentially required on a practical basis but needs a robust sampling methodology and other quality datasets to ensure accurate scaling up. • There appears to be some use of assumed yields to estimate production from the household sector based on farm numbers and farm areas. The accuracy of these yield estimates requires urgent validation.
Department of Fisheries Annual Report	• Good scope of data collection. Only source reporting seed pricing and market data. • No production by species data to fill in the interval between census reports. • The scope and structure of reported data can change from report to report, this affects the assessment of trends.

[36] Nsonga, A (2015), Status quo of Fish farming in the Northern Province of Zambia a case for Mbala and Luwingu districts, International Journal of Fisheries and Aquatic Studies 2015; 2(6): 255-258
[37] Simataa, S & Musuka, C (2013), Impact of Withdrawing Oreochromis niloticus (Nile Tilapia) from Aquaculture Production in Zambia: A Case Study of Solwezi District, International Journal of Aquaculture, 3 (27), pp 158-164.

	• The sample-based approach is potentially required on a practical basis but needs a robust sampling methodology and other quality datasets to ensure accurate scaling up. • There appears to be some use of assumed yields to estimate production from the household sector based on farm numbers and farm areas. The accuracy of these yield estimates requires urgent validation.
Periodic Research Surveys	• Data is generally very good quality and robustly collected. • Scope is very narrow and topically focussed which limits broader application and use. • Data is typically collected on an isolated basis which does not enable trend analysis.

In addition to the existing data systems described in Table 17, ZAEDP incorporates the development of a National Aquaculture Statistics Database supported by the FAO. This database will strengthen the scope, rigour and accessibility of existing industry data systems. To date, the data collection tools to support the database have been developed as part of this project. These comprise an interviewer's instruction manual, a fish farm establishments questionnaire and individual farmer questionnaire. While these tools have been developed, the initial data has not been collected due to the COVID-19 pandemic.

The Department of Fisheries, in partnership with the Zambia Bureau of Standards has commenced development of protocols around – product definitions (lifecycle), quality standards, transport standards, marking and labelling, acceptable sourcing of broodstock and fingerlings, and references to sampling and testing standards. While this is not a data collection system, it demonstrates that the appropriate procedures are in place to develop similar standards around appropriate measuring and recording of broader industry data.

The data sources described in Table 17 and Table 18 all provide valuable but limited information. The key challenge is around ensuring that accurate data is robustly collected in a uniform manner and that this is repeatable, so that trends can be observed over time. Availability of high-quality data will ensure that informed decisions can be made by policy makers and industry stakeholders, including hatchery operators.

Several important issues have been identified within Table 17 and Table 18 that affect the completeness and robustness of current industry datasets, these issues comprise:

- Key industry datasets, such as the Livestock and Fisheries Census are collected too infrequently to maintain a continuous stream of relevant data. As the only current source of data on aquaculture production species, this limits the ability to undertake regular market and industry assessments. In addition, changes in the scope and structure of the Department of Fisheries Annual Report also affect the development of continuous data records across multiple years that are essential for trend analysis.

- Survey methodologies appear to utilise assumed yields to estimate output from household systems[38]. This is a likely source of significant overestimation of production levels from the household. The 2020 Department of Fisheries Annual report cited small scale pond production of 24,023 tonnes from a pond area of 4,196 Ha, an effective yield of 5.75t/Ha. By contrast a study of 170 farmers in Northern Province by Nsonga (2015)[39] found that small-scale producers typically average 2t/ha, meanwhile Simataa and Musuka (2013)[40] found that half of small-scale producers in the North-Western Province produced just 1.5t/ha, with a third of farmers producing 1.6-4.5t/ha and only 9% producing between 4.6 and 6t/ha.
- Survey methodology, sample selection and scaling up to National/regional level appears to have inconsistencies year to year. The 2020 Department of Fisheries annual report cited small scale production (ponds and cages) of 27,394t. This contrasts with reported small scale production of only 4,741t in 2019. This highlights the need for a consistent approach nationally. Only once there is accurate and standardised reporting over time, will industry be able to get an accurate indication of industry growth and key trends.

There is strong stakeholder support for increased data collection at industry level - results from the stakeholder survey undertaken in conjunction with this report highlight that 82% of respondents support (or strongly support) improved collection and reporting of market and pricing data. Consequently, improved industry data systems offer broader benefits beyond the hatchery sector.

Key Data Gaps

Table 19 comprises an analysis of the gaps within current industry data systems from the perspective of the hatchery sector. These gaps link back to the key data types identified in Figure 18 that support the commercial and genetic improvement needs of the hatchery sector. Gaps are identified based on missing data not covered within the scope of existing industry data systems and gaps arising due to the quality/robustness of current data systems.

In addition to identifying gaps, Table 19 identifies the importance of each data type to the hatchery sector. Based on this importance and the overall extent of any data gap, an assessment is made of the urgency/priority for addressing any data gaps (Gap Urgency).

---

[38] Kaminski, A.M., Aquaculture (2017), https://doi.org/10.1016/j.aquaculture.2017.12.010

[39] Nsonga, A (2015), Status quo of Fish farming in the Northern Province of Zambia a case for Mbala and Luwingu districts, International Journal of Fisheries and Aquatic Studies 2015; 2(6): 255-258

[40] Simataa, S & Musuka, C (2013), Impact of Withdrawing Oreochromis niloticus (Nile Tilapia) from Aquaculture Production in Zambia: A Case Study of Solwezi District, International Journal of Aquaculture, 3 (27), pp 158-164.

Table 19 Gap analysis of industry data systems for Zambian hatchery operators

Key Data Type	Data availability & Primary Dataset (Green shading is high availability, red is low)	Completeness of Existing Industry Datasets (Green shading is high completeness, red is low)	Importance for Hatchery Operations and Genetic Improvement (Green shading is low importance, red is high)	Gap Urgency – Extent of gap and Importance (Green shading is low urgency, red is high)
Industry Level Data	**Moderate to High Availability.** Covered by both Livestock Census and DoF Annual Report. Census has the most complete snapshot but needs to be compiled more regularly. DoF report offers more basis data, lacking production by species and regional breakdowns.	**Moderate Completeness.** Survey/sample methodologies for the DoF Annual Reports need to support greater consistency and repeatability. Estimates of household production need to be verified as yields are not supported by other datasets.	**High Importance.** The scale and population structure of the breeding program needs to be configured to the expected market demand.	**Moderate Urgency.** Data is highly important. A basic baseline of data exists but apparent gaps exist due to collection methodologies.
Farm Level Data	**Low Availability.** Basic yield data can be inferred from Census reports and DoF annual reports. Other sources comprise isolated research surveys for farm inputs and outputs. Little coverage of detailed farm performance in routine datasets.	**Low Completeness.** None. Development of new systems for data collection are required.	**High Importance.** Data is required to support multiple commercial and genetic improvement objectives, albeit over medium to longer term horizons.	**High Urgency.** High importance to hatchery operator's commercial operations and genetic improvement strategies. Very limited current coverage within existing systems.
Hatchery & Fingerling Data	**Low Availability.** Best resource is a WorldFish survey. Some basic data is reported in the Livestock and Fisheries Census (hatchery numbers) and occasionally within the DoF Annual Report (prices).	**Moderate Completeness.** WorldFish survey provides a good snapshot of fingerling production by species and location but this is not a routine report. Other resources only provide a very small snapshot.	**Low Importance.** Data is mainly used to inform market forecasts/assessments, however these can also be derived from industry production data. Seed market prices can be tracked independently of industry datasets via informal sources.	**Low to Moderate Urgency.** Low importance to hatchery operations. Some good baseline data exists (WorldFish Survey) but this will become obsolete if not maintained.

Key Data Type	Data availability & Primary Dataset (Green shading is high availability, red is low)	Completeness of Existing Industry Datasets (Green shading is high completeness, red is low)	Importance for Hatchery Operations and Genetic Improvement (Green shading is low importance, red is high)	Gap Urgency – Extent of gap and Importance (Green shading is low urgency, red is high)
Market Data	**Moderate Availability.** Data is reported annually within DoF Annual Report. Scope usually covers import/export volumes. Monthly pricing. Data could be more granular with separation between species, region and source (capture vs culture). More detailed (but isolated) data exists within research literature.	**Moderate Completeness.** Basic data is reported annually and appears moderately robust. Data can be verified informally.	**Low to Moderate Importance.** Product and eating quality traits are more advanced and likely to be implemented over a longer time horizon. Market data is not a universal requirement for all genetic improvement functions in this area and can be informed by informal insights.	**Low to Moderate Urgency.** Low to moderate importance to hatchery operations. Some baseline data exists.

As identified in Table 19 the priority data gaps comprise:

- Collection of farm-level data, particularly data that describes farm system performance, yields and farm inputs.
- Improving the robustness of industry-level data to provide a more accurate and repeatable assessment of industry scale and structure.

Other datasets (seed and hatchery data, and market data) are of lower importance to hatchery operations, are substitutable, and subject to some existing basic coverage.

Figure 19 to Figure 21 provides an example of high-quality farm system dataset collected within Bangladesh[41]. Similar data on farm system performance allows the development of accurate and robust breeding objectives, supports the identification of new breeding traits, and informs seed pricing decisions. This is an important priority in the development of a national breeding program and will require the development of new systems for data collection.

In the context of industry level data, there is a reasonable volume of data being collected already, however, one of the key challenges is increasing the quality and repeatability of the data, as well as addressing some identified gaps in scope. Current data collection should be expanded to routinely break data into production

[41] Jahan KM, Belton B, Ali H, Dhar GC and Ara I. 2015. Aquaculture technologies in Bangladesh: An assessment of technical and economic performance and producer behaviour. Penang, Malaysia: WorldFish. Program Report: 2015-52.

by system (household vs commercial, pond vs cage), province and species. This will ensure that the hatchery sector will be better informed about the number of fingerlings required in different regions based on more detailed industry demographics and segmentation. Much of the capability to collect this data should be embedded in the existing collection systems, however, there is the opportunity to improve the overall collection methodology to address the identified gaps. Overall, improved industry data will benefit the breeding program because it will help inform the size of the breeding nucleus required (broodstock on hand and fingerling output required) and will also allow tracking of the breeding program's impact over time.

It is noted that this assessment excludes the data systems under development within ZAEDP. It is anticipated that these new systems will address some gaps identified within this report, however it was not possible to assess the scope of these proposed systems currently under development. The Department of Fisheries 2020 Annual Report also stated that an aquaculture database has been developed to collect information on feed and fish prices, as well as fish and seed production for each province quarterly. However, the scope of this new data is yet to be reported and could not be assessed.

Cost Item	Fish (HS pond)		Fish+SIS (HS pond)		Pangas (pond)		Koi (pond)		Tilapia (pond)	
	Cost (BDT)	% total costs	Cost (BDT)	% total costs	Cost (BDT)	% total costs	Cost (BDT)	% total costs	Cost (BDT)	% total costs
Total cost (BDT/HH)*	4,978		3,464		367,291		372,275		105,930	
Total cost (BDT/ha)	92,727		94,822		1,836,158		2,894,189		517,899	
Variable costs (BDT/ha)	76,610	83	80,129	85	1,764,833	96	2,826,381	98	489,169	93
Fish seed	40,816	46	46,368	50	227,042	14	338,073	12	80,019	18
Organic fertilizer	2,157	3	2,557	3	1,060	0.13	6	0	2,348	1
Inorganic fertilizer	3,263	3	2,997	3	3,195	0.31	281	0.02	7,455	3
Chemicals	2,142	3	2,491	3	11,963	1	29,119	1	8,664	2
Feed	15,595	15	10,339	11	1,432,351	75	2,324,899	80	330,127	53
Labor	6,179	7	9,528	10	62,150	4	82,914	3	41,452	12
Other (water supply, repairs, marketing, etc.)	6,458	6	5,848	6	27,073	2	51,088	2	19,103	4
Fixed costs (BDT/ha)	16,116	17	14,693	15	71,324	4	67,809	2	28,731	7
Depreciation	15,154	16	13,914	14	35,551	2	43,217	2	18,537	5
Rental	467	0.21	0	0	18,067	1	4,699	0.15	5,156	1
Other (land tax, interest on loan, etc.)	495	1	779	1	17,706	1	19,893	1	5,038	1

Figure 19 Example of high-quality farm system data from Jahan et al (2015).

Fish species name	Fish (HS pond)		Fish+SIS (HS pond)		Pangas (pond)		Koi (pond)		Tilapia (pond)	
	Cost	% total costs	Cost	% total costs	Cost	% total costs	Cost	% total costs	Cost	% total costs
Total stocking cost (BDT/HH)	2,135	-	1,665	-	47,412	-	42,861	-	15,238	-
Total stocking cost (BDT/ha)	40,816	100	46,368	100	227,042	100	338,073	100	80,019	100
Indian major carp	21,675	53	12,687	27	23,610	10	5,409	2	13,772	17
Exotic carps	13,279	33	14,825	32	11,248	5	5,071	2	7,959	10
Indian minor carp	1,860	5	4,196	9	716	0.32	-	-	242	0.30
Small indigenous species	90	0.22	3,816	8	-	-	-	-	46	0.06
Shing	146	0.36	116	0.25	199	0.09	63,942	19	3,557	4
Pangas	275	1	-	-	186,890	82	-	-	337	0.42
Tilapia	3,063	8	252	1	4,289	2	6,842	2	50,243	63
Koi	96	0.24	-	-	-	-	256,809	76	2,983	4
Other	155	0.38	61	0.13	91	0.04	-	-	10	0.01
Prawn	175	0.43	10,415	22	-	-	-	-	868	1
Tiger shrimp	-	-	-	-	-	-	-	-	-	-
Other shrimp	-	-	-	-	-	-	-	-	-	-

Figure 20 Example of high-quality farm system data from Jahan et al (2015)

Production	Fish (HS pond)		Fish+SIS (HS pond)		Pangas (pond)		Koi (pond)		Tilapia (pond)	
	Production	% total production	Production	% total production	Production	% total production	Production	% total production	Production	% total production
Total fish production (kg/HH)	95	-	59	-	6,373	-	4,285	-	1,920	-
Total fish production (kg/ha)	1,759	100	1,687	100	32,688	100	33,036	100	8,856	100
Indian major carp	758	43	559	33	1,571	5	152	0.46	1,035	12
Exotic carps	708	40	681	40	1,162	4	95	0.29	1,028	12
Indian minor carp	72	4	177	10	43	0.13	-	-	13	0.15
Small indigenous species	42	2	227	13	2	0.01	-	-	13	0.14
Shing	6	0.35	3	0.18	5	0.01	964	3	118	1
Pangas	13	1	-	-	29,324	90	-	-	35	0.40
Tilapia	127	7	3	0.19	567	2	1,253	4	6,279	71
Koi	3	0.19	-	-	-	-	30,572	93	314	4
Other	30	2	13	1	13	0.04	-	-	17	0.19
Prawn	1	0.06	24	1	-	-	-	-	5	0.06
Tiger shrimp	-	-	-	-	-	-	-	-	-	-
Other shrimp	-	-	-	-	-	-	-	-	-	-

Figure 21 Example of high-quality farm system data from Jahan et al (2015)

Strategies for Collection of Key Datasets

It is recognised that resourcing (funding and availability of trained staff) is likely a key constraint impacting current data collection systems, particularly given the logistical challenges of field data collection in Zambia. When operating under these constraints the focus for Government should be on reducing the frequency of collection to ensure higher quality data is obtained – for example, biennial collection of industry statistics may allow more accurate prediction of nationwide production by enabling more targeted use of resources. More targeted use of resources also releases funding and capacity to support greater investment in staff training, methodology development, integration of external support and development of technology platforms to support collection. Biennial collection of higher quality data is adequate to meet most needs, ensuring adequate frequency to maintain data relevance and allowing industry trends to be extrapolated.

Outsourcing is a viable strategy to support improved data collection systems. This can reduce constraints/demands on Departmental key staff and also support the strategic use of external expertise to manage more complex data collection assignments. Good quality farm system data is complex, with onerous sampling and surveying of participants required. Input from relevant research for development organisations experienced in collecting this type of data, would be advantageous. This could be undertaken at three-to-five-year intervals if cost would otherwise make this a prohibitive factor in engaging external support.

Thought should be given to consistency of measurements across enumerators and technical staff involved in data collection. Standardised training of officers and undertaking regular reconciliations across provinces/regions should help to improve data integrity. Creating consistent and repeatable surveys will enable trends to be established and analysed.

Looking forward it may be that some data collection can be automated using GIS/satellite imagery technology, however, this requires robust industry data to develop and calibrate these methodologies and therefore wouldn't be possible for some time. In the meantime, it is likely that surveys remain the key instrument for data collection.

This report focuses on the industry data requirements to support the hatchery sector and particularly the GIP. It is recognised that the data requirements and identified gaps are specific to the needs of this industry segment and not intended to reflect the requirements of broader industry stakeholders.

Data collection systems need to be designed to cater to the particular needs of a broad range of stakeholders. It is likely that more sophisticated data and data systems are required by other industry stakeholders and policy makers.

To this end it is noted that the FAO, through the Coordinating Working Party on Fisheries Statistics (CWP), is developing advice for Governments and policy makers on the requirements, standards, definitions and methodologies for the collection of national fisheries and aquaculture statistics[42].

---

[42] See: http://www.fao.org/cwp-on-fishery-statistics/background/en/

The CWP standards for Aquaculture Statistics were reviewed. The scope of statistical data contained within these standards is sufficient to meet the data and information needs of the Zambian hatchery sector, as described in this report[43].

The CWP standards for aquaculture statistics are developed to meet the needs for fisheries and aquaculture research, policy development and industry management. Consequently, these standards could form the basis of a longer-term scope and specification for Zambian fisheries and aquaculture statistics that will meet the diverse data and information needs of key stakeholders, including the hatchery and genetic improvement sector.

Key Findings & Recommendations

Table 20 summarises the key findings from the assessment of the commercial sustainability of the Three Spotted Tilapia GIP.

Table 20 Summary of key findings – industry data systems

Topic	Key Findings
Data and information needs for the hatchery sector	• Hatcheries use data to support commercial decisions and genetic improvement. • Commercial industry data is hard to use within genetic evaluations but can inform other important genetic improvement requirements. • The key data requirements to support commercial operations comprise industry data (size and distribution of aquaculture industry), farm systems and farm performance, and hatchery and fingerling production statistics. This data ultimately informs fingerling and market assessments and identifies key segments for fingerling sales and distribution logistics. • The key data requirements to support genetic improvement functions comprise industry data (size and distribution of aquaculture industry), farm systems and farm performance, and market data for harvested fish (pricing, market channels, weights/yields etc). This data supports functions such as shaping nucleus population and population structure, identifying traits to performance record and setting breeding objectives and selection indexes.
Key data gaps for the hatchery sector	• Public data available for the Zambian aquaculture sector predominately comprises the Ministry of Livestock and Fisheries Census, the Department of Fisheries Annual Report, and various research surveys. • ZAEDP has commissioned the development of a fisheries and aquaculture statistics database with support from FAO. The data collection tools have been developed but data is not yet collected and the system is not operational. • A gap analysis identified the key data gaps as comprising farm system and farm performance data, and more robust industry-level statistics. Other data requirements are either adequately covered by existing systems or of lower value to the hatchery sector. • Gaps associated with industry level data largely reflect apparent challenges with survey frequency and repeatability, and apparent inconsistencies created by survey methodologies that impact robustness of the dataset.
Strategies for improved data systems	• It is recognised that resourcing (funding and availability of trained staff) is likely a key constraint impacting current data collection systems.

[43] See: http://www.fao.org/3/i4034e/i4034e.pdf

	- To manage resource constraints Government can consider less frequent collection to enable more investment into training/support, methodology development, and survey technologies. Strategic outsourcing could also be considered for more complex data. - Survey frequency of biannual (two-yearly) and up to five-yearly may be sufficient for some data types as this is frequent enough to retain relevance and support extrapolation of trends. - Industry data systems need to meet the needs of diverse stakeholders. Requirements for the hatchery sector may not align with broader needs of other stakeholders. - FAO CWP guidelines for aquaculture statistics cover the scope of requirements for the Zambian hatchery sector and could form a longer-term target for data collection and reporting systems.

Based on the above, a series of recommendations (Table 21) have been proposed to progress Government and industry decision making over the scope and requirements for data systems to support the hatchery sector and the GIP.

Table 21 Recommendations – industry data systems

Recommendation	Description
Recommendation 1 Review scope of ZAEDP survey tools.	Prior to implementation of the FAO survey tools that support the aquaculture statistical database to be commissioned under ZAEDP, **an assessment should be undertaken of the scope of these tools to ensure coverage of the urgent gaps identified in this report.**
Recommendation 2 Review data collection systems and identify opportunities to improve efficacy.	Current data systems cover a basic scope of data that meets much of the hatchery sectors needs but are undermined by data robustness. **The Zambian Government should engage with relevant research for development organisations to review broader industry survey systems, methodologies, and staff requirements to support improved efficacy of industry survey systems.** This should be in accordance with the strategies described in this report. The review must target opportunities to increase the efficacy of existing data collection systems via more effective use of resources.
Recommendation 3 Develop a long-term data system development strategy.	**In concert with Recommendations 1 and 2, the Government should develop a long-term strategy for development of their aquaculture and fisheries statistics.** This strategy could adopt the FAO CWP standards as the long-term target, identifying an implementation plan and milestones to transition to this target from current systems. The strategy needs to be supported by cost-benefit analysis to determine the data collection scope, ensuring data collection activities are generating with industry impacts that exceed their cost. Industry engagement in the scope and delivery of the strategy is required.
Recommendation 4 Commission the undertaking of a farm-system survey to fill urgent data gap.	Subject to the outcomes from Recommendations 1-3 and the timeliness with which quality farm system data will be collected and reported, **Government should commission a detailed farm system survey from a relevant research for development organisation and repeat on an agreed interval**. This data is a critical gap within the scope of current systems, and has broad applicability beyond the needs of the hatchery sector, helping support policy development and inform other data collection systems.

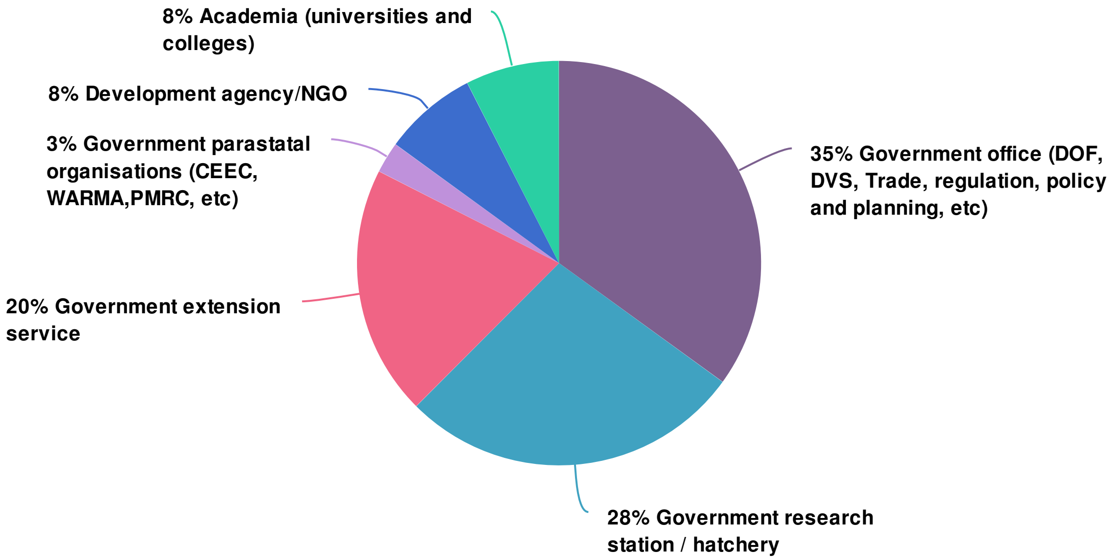
Annex 1

Report for Zambia Aquaculture - Government and Research FINAL

Response Counts

Completion Rate:	**57.4%**	
	Complete	39
	Partial	29
		Totals: 68

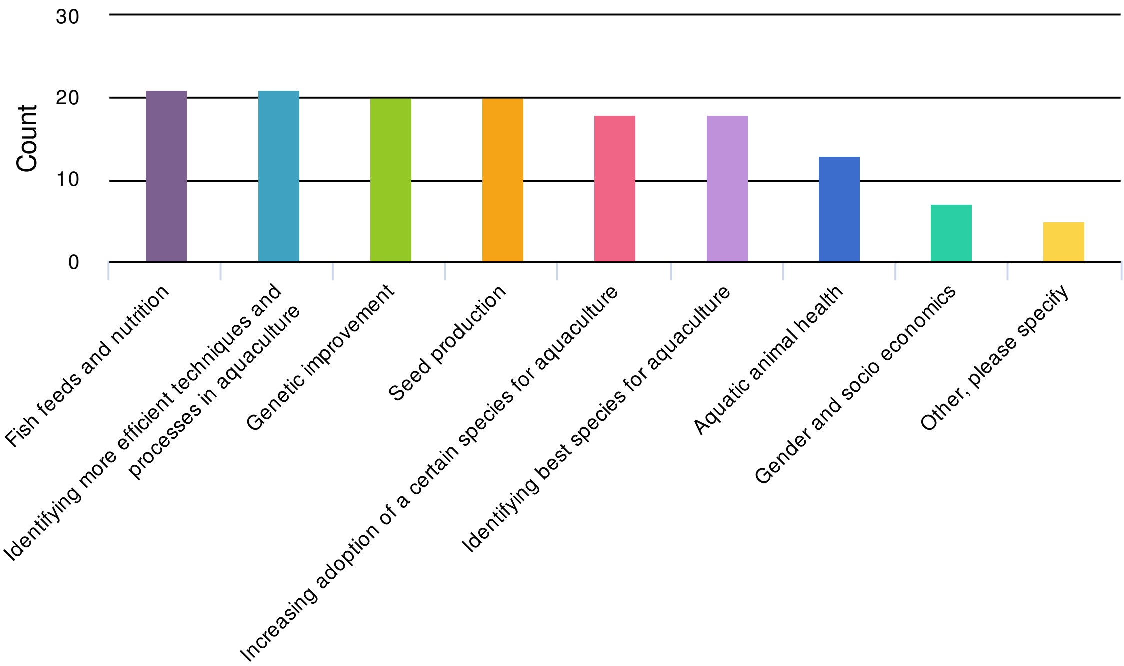
1. Which area do you work in?



Value	Percent	Responses
Government office (DOF, DVS, Trade, regulation, policy and planning, etc)	35.0%	14
Government research station / hatchery	27.5%	11
Government extension service	20.0%	8
Government parastatal organisations (CEEC, WARMA,PMRC, etc)	2.5%	1
Development agency/NGO	7.5%	3
Academia (universities and colleges)	7.5%	3
		Totals: 40

Other, please specify	Count
Totals	0

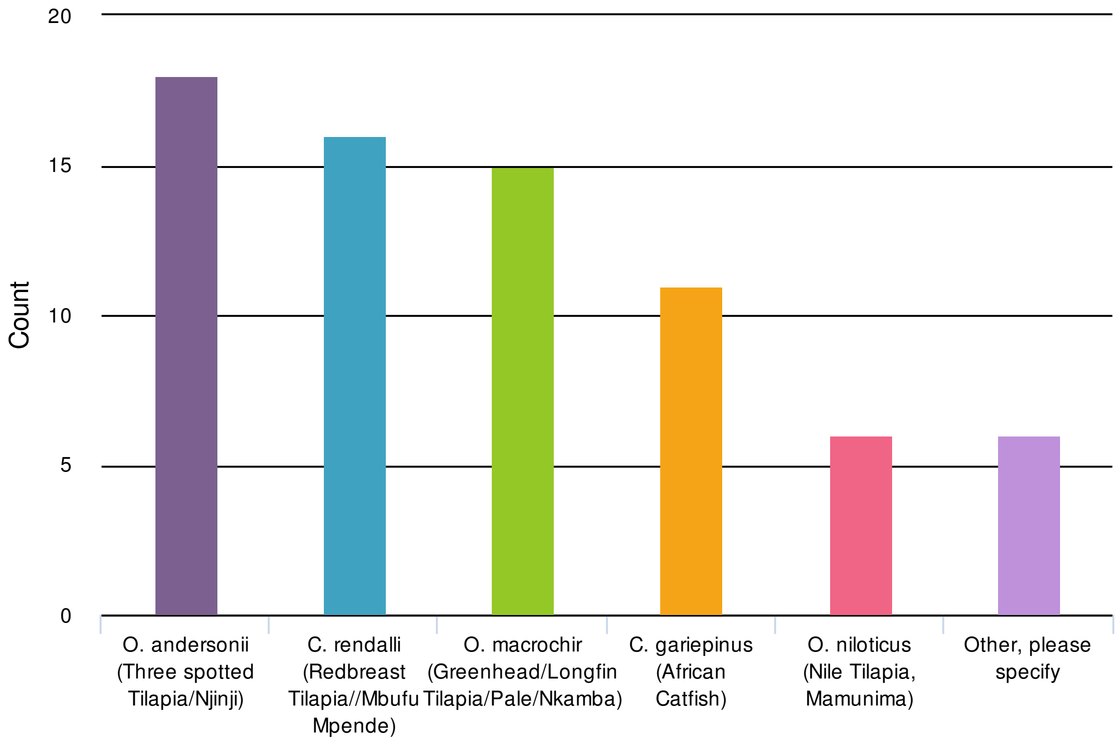
2. If working in a research organisation, what are your main research objectives in aquaculture? Please select all that apply



Value	Percent	Responses
Fish feeds and nutrition	63.6%	21
Identifying more efficient techniques and processes in aquaculture	63.6%	21
Genetic improvement	60.6%	20
Seed production	60.6%	20
Increasing adoption of a certain species for aquaculture	54.5%	18
Identifying best species for aquaculture	54.5%	18
Aquatic animal health	39.4%	13
Gender and socio economics	21.2%	7
Other, please specify	15.2%	5

Other, please specify	Count
Finding new methods of improving fish processing	1
I don't work in research but extension in KASEMPA	1
Research Administration	1
Training Institution	1
increase in fish production	1
Totals	5

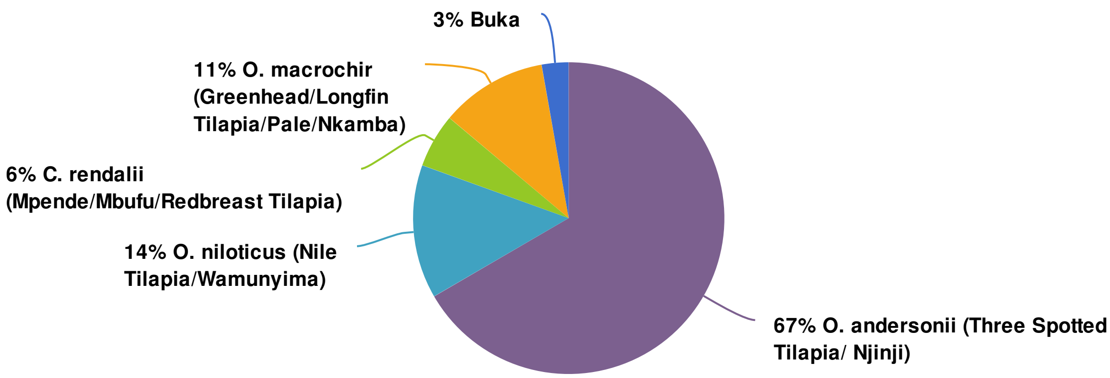
3. If working in a government or private organization hatchery, which species do you farm?



Value		Percent	Responses
O. andersonii (Three spotted Tilapia/Njinji)		64.3%	18
C. rendalli (Redbreast Tilapia//Mbufu Mpende)		57.1%	16
O. macrochir (Greenhead/Longfin Tilapia/Pale/Nkamba)		53.6%	15
C. gariepinus (African Catfish)		39.3%	11
O. niloticus (Nile Tilapia, Mamunima)		21.4%	6
Other, please specify		21.4%	6

Other, please specify	Count
A. occidentalis (Giraffe catfish)	1
All the listed	1
Carpfush	1
O.tanganicae, Cyprinus carpio	1
We promote culture of three spotted bream & O. Macrochir	1
Totals	5

7. What do you view as the most important species to Zambian aquaculture?



Value	Percent	Responses
O. andersonii (Three Spotted Tilapia/ Njinji)	66.7%	24
O. niloticus (Nile Tilapia/Wamunyima)	13.9%	5
C. rendalii (Mpende/Mbufu/Redbreast Tilapia)	5.6%	2
O. macrochir (Greenhead/Longfin Tilapia/Pale/Nkamba)	11.1%	4
Buka	2.8%	1
		Totals: 36

Other - please specify	Count
Totals	0

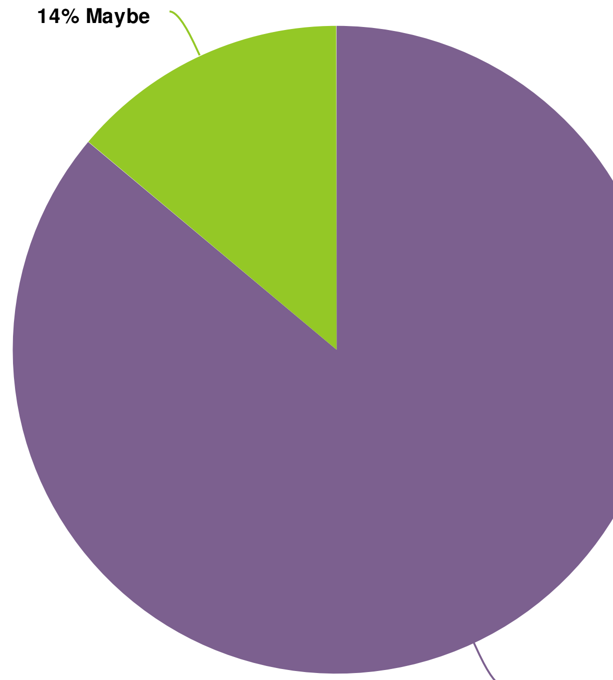
8. Do you agree with the following statements for your choice on the most important aquaculture species?

	Strongly disagree	Disagree	Slightly agree	Agree	Strongly agree	Responses
Performs better than other species in extensive and semi-intensive farms Count Row %	2 5.9%	1 2.9%	3 8.8%	23 67.6%	5 14.7%	34
Performs better than other species in intensive farms Count Row %	0 0.0%	1 3.0%	4 12.1%	21 63.6%	7 21.2%	33
Is fast growing Count Row %	0 0.0%	1 2.9%	4 11.4%	20 57.1%	10 28.6%	35
Is easy to sell to consumers Count Row %	0 0.0%	0 0.0%	0 0.0%	14 40.0%	21 60.0%	35
Achieves highest market prices Count Row %	0 0.0%	2 5.7%	4 11.4%	22 62.9%	7 20.0%	35
Is an important option for farmers to grow in some regions Count Row %	2 5.6%	0 0.0%	1 2.8%	15 41.7%	18 50.0%	36
Has support from Government as a preferred species Count Row %	1 2.9%	3 8.6%	5 14.3%	10 28.6%	16 45.7%	35
Easy to feed and grow Count Row %	0 0.0%	1 2.9%	0 0.0%	14 40.0%	20 57.1%	35

	Strongly disagree	Disagree	Slightly agree	Agree	Strongly agree	Responses
Well adapted to Zambia climatic and environmental conditions Count Row %	1 2.8%	0 0.0%	0 0.0%	16 44.4%	19 52.8%	36
Seed is readily available Count Row %	0 0.0%	0 0.0%	9 25.7%	18 51.4%	8 22.9%	35
Preferred by consumers Count Row %	0 0.0%	0 0.0%	5 14.3%	18 51.4%	12 34.3%	35
Disease resistance :Do you agree with the following statements for your choice on ***the most important aquaculture species***? Count Row %	0 0.0%	0 0.0%	0 0.0%	1 100.0%	0 0.0%	1
Disease resistant:Do you agree with the following statements for your choice on ***the most important aquaculture species***? Count Row %	0 0.0%	0 0.0%	0 0.0%	0 0.0%	1 100.0%	1
Does not easily succumb to disease:Do you agree with the following statements for your choice on ***the most important aquaculture species***? Count Row %	0 0.0%	0 0.0%	0 0.0%	0 0.0%	1 100.0%	1

	Strongly disagree	Disagree	Slightly agree	Agree	Strongly agree	Responses
Fairly compete with other recommended species:Do you agree with the following statements for your choice on ***the most important aquaculture species***? Count Row %	0 0.0%	0 0.0%	0 0.0%	0 0.0%	1 100.0%	1
prefered by commercial farmers as it is relatively hardy with higher survival:Do you agree with the following statements for your choice on ***the most important aquaculture species***? Count Row %	0 0.0%	0 0.0%	0 0.0%	0 0.0%	1 100.0%	1
Totals Total Responses						36

9. Do you believe that Three Spotted Tilapia (Njini) will be important for development of aquaculture production in Zambia going forward?



Value		Percent	Responses
Yes		86.1%	31
Maybe		13.9%	5

Totals: 36

10. Why did you choose your response above?

ResponseID	Response
11	It is relatively better than the other indigenous species in terms of growth performance and availability of seed
16	It has a good growth rate, disease resistance and adapts well to Zambian climate
19	Because it has the record of fast growth
20	It has potential to grow big and can grow in most parts of Zambia
21	Its widely accepted and has been doing fine in our local waters
22	With the current genetic improvement programme, I believe O.andesonii will have the best traits in the industry
24	It is endemic to most parts of Zambia with an exception for Luapula, Northern and Muchinga Provinces where it is cultured on farms that have proven through assessment and audit that it will not find its way into the stream, rivers or lakes etc. The Three Spotted tilapia is highly dispersed in the other seven provinces making it an important species for aquaculture development in Zambia.
25	Easy to handle at various levels and preferred by consumers
27	-High performance & adaptability -Generally acceptable in all regions
29	It provides an option for other species that can be cultured apart from niloticus
30	Promotion of the said species by Government and because of the Genetic Improvement Programme of O. andersonii
33	We have used it in the past and appears promising
35	It's easier to grow and c as n easily adapt to the environment
38	Three Spotted is fast growing and indigenous to Zambia.
39	Well adapted to Zambia climatic and environmental conditions and has a lot of support from the government
40	Because of its tolerance, fast growing, easy to manage characteristics
43	Its an indigenous species and readily available
45	Due to its demand on the market

ResponseID	Response
46	It also depend on the demand for the majority of the people in Zambia as well consistent Government Policy
47	Because the species is found in almost all regions in Zambia and easily accepted by consumers.
48	High consumer preference and a good fcr.
49	It's a specie that is found in zambezi and Kafue therefore can be cultured in 7 provinces in zambia
50	Not fully exploited species among farmers
51	It is relatively easy to culture and is quite tasty
53	Oreochromis niloticus will be every businessmans' preferred option. The "biodiversity" talk has not really been convincing; more needs to be done in the communication department to explain the basis of promoting O. andersonii at expense of exotics.
57	It's fast growing and accepted by consumers
60	Given current state does it grow fast as in niloticus
61	It is adaptable to our local climate. It is early to collect the original spp. from our natural water bodies. It can easily be cultured in 7 provinces of Zambia
62	Good adaptation
64	It's fast growing and preferred by consumers
65	It is an indigenous fish species which has adapted to climatic and environment conditions. Above all ,previous research has shown that it grows as fast as exotic fish O.niloticus
71	The three spotted bream grows fast, attains table size fast. It's very attractive to customers and very taste.

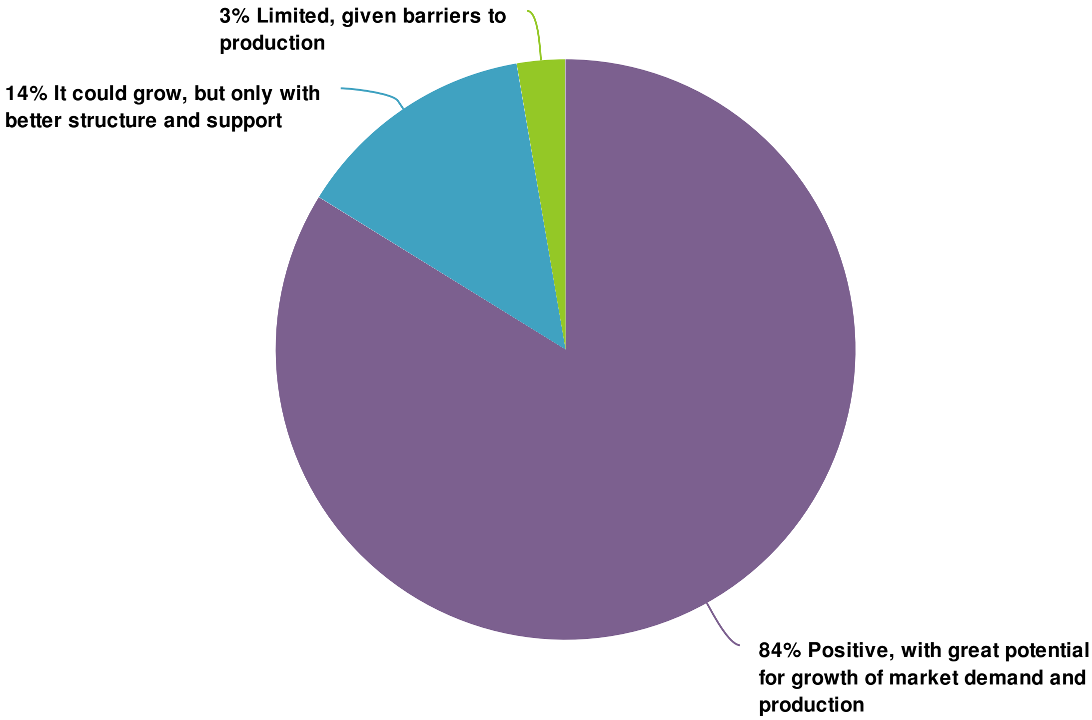
11. What is your perception of Three Spotted Tilapia (Njinji)?

	Strongly disagree	Disagree	Slightly agree	Agree	Strongly agree	Responses
Performs better than other species in extensive and semi-intensive farms Count Row %	1 2.9%	4 11.8%	7 20.6%	17 50.0%	5 14.7%	34
Performs better than other species in intensive farms Count Row %	0 0.0%	3 8.6%	10 28.6%	20 57.1%	2 5.7%	35
Is fast growing Count Row %	1 2.9%	1 2.9%	7 20.0%	18 51.4%	8 22.9%	35
Is easy to sell to consumers Count Row %	0 0.0%	1 2.9%	2 5.7%	15 42.9%	17 48.6%	35
Achieves highest market prices Count Row %	0 0.0%	2 5.9%	6 17.6%	18 52.9%	8 23.5%	34
Is the only option for farmers to grow in some regions of Zambia Count Row %	0 0.0%	5 14.3%	3 8.6%	16 45.7%	11 31.4%	35
Has support from Government Count Row %	1 2.8%	0 0.0%	5 13.9%	12 33.3%	18 50.0%	36
Easy to feed and grow Count Row %	0 0.0%	1 2.9%	3 8.6%	19 54.3%	12 34.3%	35

	Strongly disagree	Disagree	Slightly agree	Agree	Strongly agree	Responses
Well adapted to Zambia climatic and environmental conditions Count Row %	2 5.6%	0 0.0%	3 8.3%	16 44.4%	15 41.7%	36
Seed is readily available Count Row %	0 0.0%	5 14.3%	11 31.4%	15 42.9%	4 11.4%	35
Preferred by consumers Count Row %	0 0.0%	2 5.7%	6 17.1%	22 62.9%	5 14.3%	35
Adapts easily under polyculture in extensive farms:What is your perception of ***Three Spotted Tilapia (Njinji)***? Count Row %	0 0.0%	0 0.0%	0 0.0%	0 0.0%	1 100.0%	1
It indigenous and readily available:What is your perception of ***Three Spotted Tilapia (Njinji)***? Count Row %	0 0.0%	0 0.0%	0 0.0%	1 100.0%	0 0.0%	1
It's a tasty fish:What is your perception of ***Three Spotted Tilapia (Njinji)***? Count Row %	0 0.0%	0 0.0%	0 0.0%	1 100.0%	0 0.0%	1

	Strongly disagree	Disagree	Slightly agree	Agree	Strongly agree	Responses
Resistance to diseases :What is your perception of ***Three Spotted Tilapia (Njinji)***? Count Row %	0 0.0%	0 0.0%	0 0.0%	1 100.0%	0 0.0%	1
Totals Total Responses						36

12. What do you believe to be the outlook for the aquaculture industry in Zambia?



Value	Percent	Responses
Positive, with great potential for growth of market demand and production	83.8%	31
It could grow, but only with better structure and support	13.5%	5
Limited, given barriers to production	2.7%	1

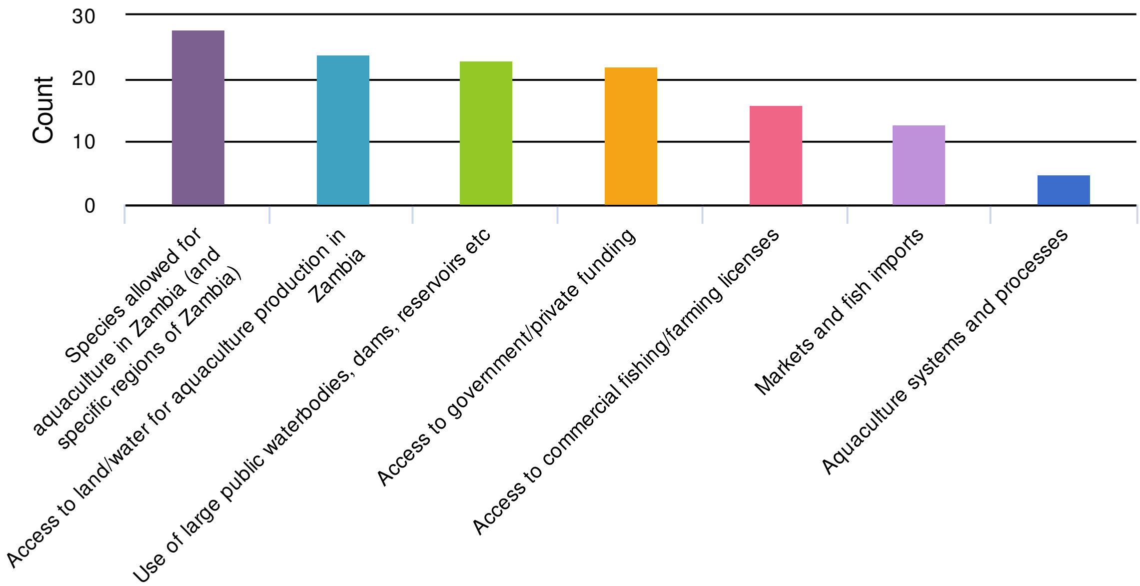
Totals: 37

13. Which opportunities have the greatest potential to increase production from the aquaculture industry in Zambia?

	Strongly disagree	Disagree	Slightly agree	Agree	Strongly agree	Responses
Improved access to land/water for development of aquaculture sites Count Row %	3 8.3%	0 0.0%	4 11.1%	11 30.6%	18 50.0%	36
Adoption of more intensive aquaculture systems (e.g. cage culture) Count Row %	3 8.6%	1 2.9%	1 2.9%	13 37.1%	17 48.6%	35
Increased production via availability of better seed Count Row %	2 5.6%	1 2.8%	0 0.0%	6 16.7%	27 75.0%	36
Increased production via availability of better feed Count Row %	3 8.3%	1 2.8%	0 0.0%	5 13.9%	27 75.0%	36
Increased production via the adoption of improved management practices Count Row %	1 2.9%	1 2.9%	0 0.0%	7 20.0%	26 74.3%	35
Declining output from capture fisheries Count Row %	0 0.0%	4 11.8%	8 23.5%	9 26.5%	13 38.2%	34

	Strongly disagree	Disagree	Slightly agree	Agree	Strongly agree	Responses
Growing demand from local consumers Count Row %	2 5.6%	1 2.8%	0 0.0%	12 33.3%	21 58.3%	36
Development of export markets Count Row %	1 2.9%	1 2.9%	2 5.7%	12 34.3%	19 54.3%	35
Development of processing capacity and opportunities to value addition Count Row %	1 2.9%	0 0.0%	1 2.9%	14 40.0%	19 54.3%	35
Improved access to finance and grants Count Row %	2 5.6%	0 0.0%	1 2.8%	9 25.0%	24 66.7%	36
Improvement of other local species Count Row %	0 0.0%	0 0.0%	0 0.0%	1 100.0%	0 0.0%	1
Totals Total Responses						36

14. Which areas are strongly regulated by Government policy and regulations?



Value	Percent	Responses
Species allowed for aquaculture in Zambia (and specific regions of Zambia)	75.7%	28
Access to land/water for aquaculture production in Zambia	64.9%	24
Use of large public waterbodies, dams, reservoirs etc	62.2%	23
Access to government/private funding	59.5%	22
Access to commercial fishing/farming licenses	43.2%	16
Markets and fish imports	35.1%	13
Aquaculture systems and processes	13.5%	5

Other, please specify	Count
Totals	0

15. What presents the biggest challenge/barrier to the development of aquaculture in Zambia?

	Strongly disagree	Disagree	Slightly agree	Agree	Strongly agree	Responses
Limited access to land/water Count Row %	2 5.7%	6 17.1%	7 20.0%	12 34.3%	8 22.9%	35
Limited availability of good quality seed Count Row %	2 5.4%	0 0.0%	3 8.1%	16 43.2%	16 43.2%	37
Difficulty of supply of feed, fertilisers, and other fish farming products Count Row %	1 2.9%	0 0.0%	5 14.3%	11 31.4%	18 51.4%	35
Consumer demand is variable and price sensitive Count Row %	2 5.6%	10 27.8%	14 38.9%	8 22.2%	2 5.6%	36
The price received for selling fish is too low Count Row %	5 13.9%	15 41.7%	11 30.6%	4 11.1%	1 2.8%	36
Competition from imported fish Count Row %	2 5.4%	7 18.9%	7 18.9%	10 27.0%	11 29.7%	37
Lack of infrastructure to support market access and distribution of fish Count Row %	1 2.9%	1 2.9%	11 32.4%	7 20.6%	14 41.2%	34
Lack of funding/subsidies/incentives for aquaculture Count Row %	1 2.8%	1 2.8%	7 19.4%	16 44.4%	11 30.6%	36

	Strongly disagree	Disagree	Slightly agree	Agree	Strongly agree	Responses
Lack of finance for fish farmers Count Row %	1 2.8%	1 2.8%	11 30.6%	9 25.0%	14 38.9%	36
Lack of skilled labour and expertise Count Row %	1 2.8%	4 11.1%	13 36.1%	10 27.8%	8 22.2%	36
Lack of technical support and expertise Count Row %	2 5.6%	6 16.7%	12 33.3%	6 16.7%	10 27.8%	36
Lack of well-defined policy and regulations Count Row %	0 0.0%	0 0.0%	0 0.0%	0 0.0%	1 100.0%	1
Water in some parts if the country Count Row %	0 0.0%	0 0.0%	0 0.0%	1 100.0%	0 0.0%	1
Totals Total Responses						37

16. What interventions could the Government make to support the growth and development of the industry?

	Strongly disagree	Disagree	Slightly agree	Agree	Strongly agree	Responses
Make it easier to obtain aquaculture licenses Count Row %	1 2.9%	2 5.9%	3 8.8%	18 52.9%	10 29.4%	34
Make it easier to access aquaculture sites in major reservoirs and water bodies Count Row %	0 0.0%	0 0.0%	2 6.1%	17 51.5%	14 42.4%	33
Reinforce geographic restrictions on the use of specific fish species Count Row %	1 2.9%	4 11.4%	3 8.6%	12 34.3%	15 42.9%	35
Invest in the delivery of technical support and advisory services Count Row %	0 0.0%	0 0.0%	1 2.9%	12 35.3%	21 61.8%	34
Provide grants or access to finance to support development of aquaculture projects Count Row %	0 0.0%	1 2.9%	2 5.7%	7 20.0%	25 71.4%	35
Improve the collection and reporting of market and pricing data Count Row %	0 0.0%	0 0.0%	2 5.7%	21 60.0%	12 34.3%	35

	Strongly disagree	Disagree	Slightly agree	Agree	Strongly agree	Responses
Improve the collection and reporting of industry production statistics Count Row %	0 0.0%	0 0.0%	2 5.7%	18 51.4%	15 42.9%	35
Support the development of infrastructure to improve market access Count Row %	0 0.0%	0 0.0%	0 0.0%	18 54.5%	15 45.5%	33
Restrict volumes of imported fish products to improve prices for local fish Count Row %	0 0.0%	2 5.9%	1 2.9%	6 17.6%	25 73.5%	34
Support development of hatcheries and breeding programs to improve seed/fingerling supply Count Row %	1 2.8%	0 0.0%	1 2.8%	4 11.1%	30 83.3%	36
Improve the indigenous fish species Count Row %	0 0.0%	0 0.0%	0 0.0%	0 0.0%	1 100.0%	1
Totals Total Responses						36

17. Which regions do you believe will have the most contribution/be most important to Zambian aquaculture going forward? Please rank the top 3

Item	Overall Rank	Rank Distribution	Score	No. of Rankings
Southern	1		262	29
Luapula	2		252	28
Northern	3		165	20
North Western	4		106	15
Lusaka	5		99	16
Copperbelt	6		71	11
Western	7		68	12
Muchinga	8		64	11
Central	9		56	10
Eastern	10		38	8

Lowest Rank Highest Rank

18. If you have any additional comments, please leave them in the text box.

ResponseID	Response
11	None
24	Luapula Province has most of the water in Zambia making it the region with the highest potential for aquaculture development for inland (ponds) and out-land (cages) farming.
25	Strengthening extension service delivery is also very crucial
27	There is need to avail the fisheries and policy targeting specific guidelines on Aquaculture development
33	Capacity should be built in extension staff
45	Capacity building for extension officers should increase
48	Of late government has placed emphasis on the growth of the Aquaculture sector
53	One of the greatest inhibitions to growth, and adoption of aquaculture is the heavy reliance on capture fisheries. Therefore, a region merely possessing an abundance of water resources may not translate to high aquaculture productivity - unless of course the practioneers are from other regions (foreign investors). A case in point is Central Provinces' Itezhi-tezhi and Kapiri Districts.
61	Current fingerling size(1-2g) being promoted are not best for a 6 months production cycle. A fingerling should be from 5g - 10g.
62	Nil
65	I suggest question 7 should have a variety of species choice rather than restricting to one answer in view of avoiding translocation

This report is filtered
Only show: Question "WorldFish and AbacusBio in collaboration with the Ministry of Fisheries and Livestock under the Zambia Aquaculture Enterprise and Development Project (ZAEDP), are carrying out research consultations to generate information to develop the dissemination strategy for improved Three-Spotted Tilapia in Zambia.

We would like to have your voluntary contribution. You are at liberty to decline the interview or stop it at any time you wish to do so. If you accept to respond, be aware that all the information you provide will be anonymised and kept confidential, thus your name and other personal identifiers will not appear in any data that is made publicly available. The information you provide will be used purely for research purposes. The interview should take about 20 minutes and your responses will be captured on the tablet.

There are no mandatory questions, so if you prefer not to answer some of the questions this is perfectly fine. You may ask questions before agreeing to participate, at any time during the study, and if after the study you have any questions, you can contact the Project PI Dr Rose K. Basiita from WorldFish at [+260971797476]. You may raise any concerns or complaints through email on b.komugisha@cgiar.org.

Your opinion is extremely valuable to us!

Do you accept to provide information?" is one of the following answers ("Yes")

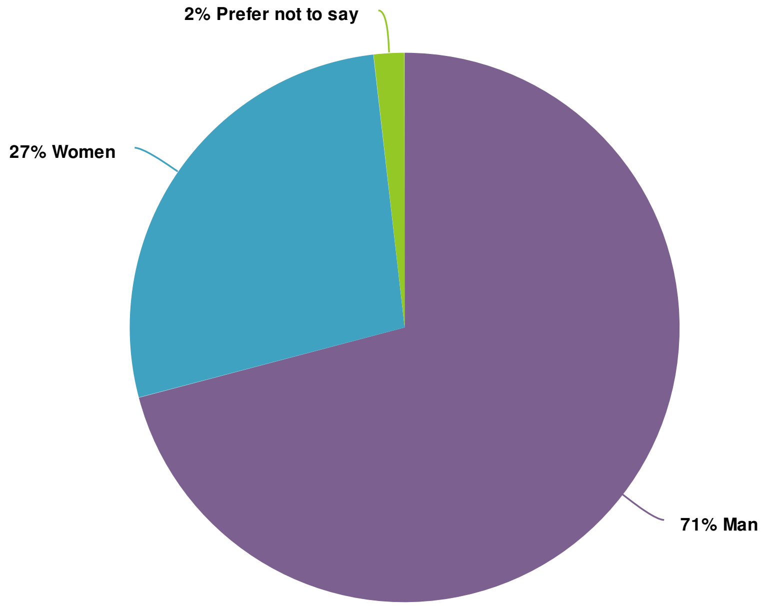
Report for Zambia Aquaculture - Farmer Survey - FINAL

Response Counts

Completion Rate:	**78.3%**	
	Complete	47
	Partial	13

Totals: 60

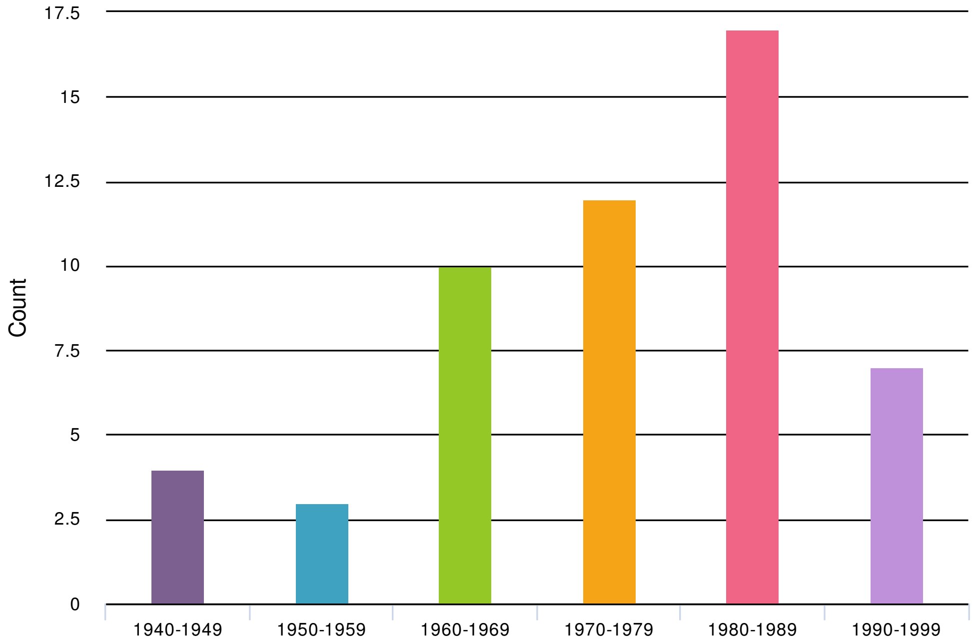
1. Your gender?



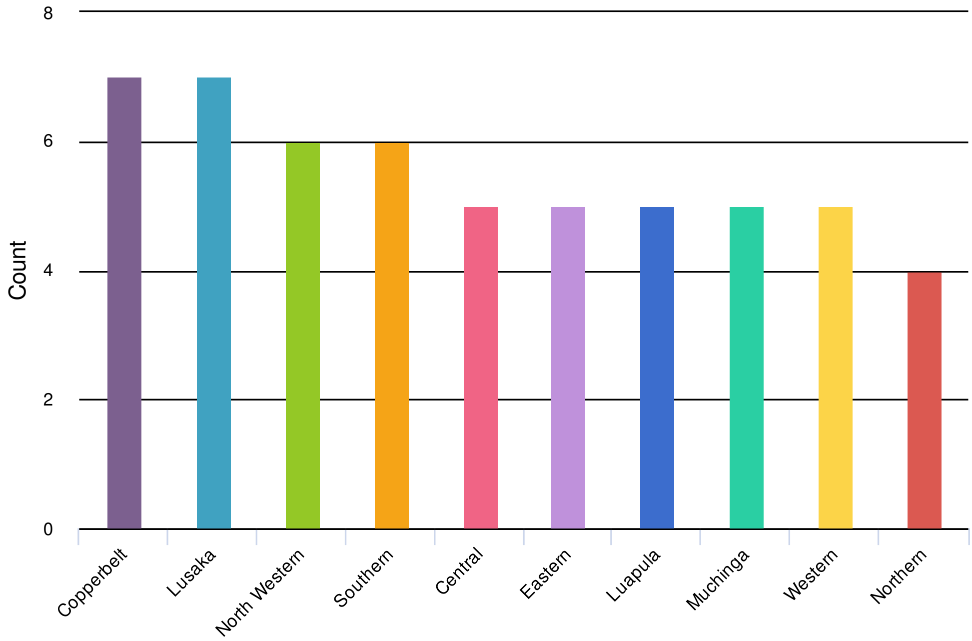
Value		Percent	Responses
Man		70.9%	39
Women		27.3%	15
Prefer not to say		1.8%	1

Totals: 55

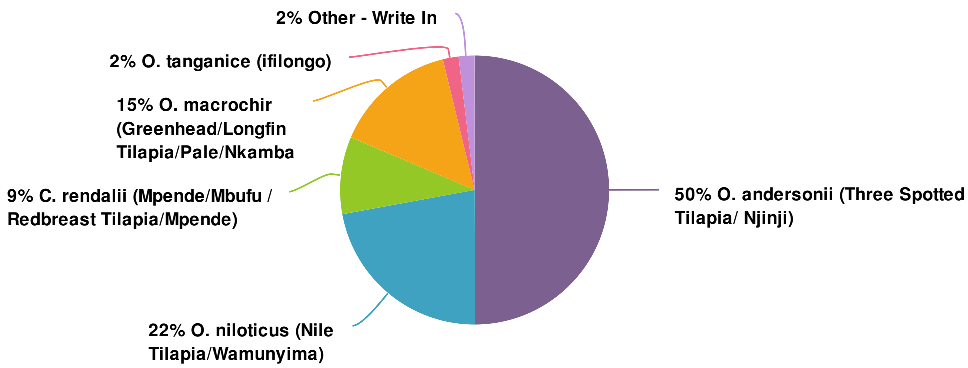
2. What is your year of birth?



3. Which province of Zambia is your farming/production operation located?



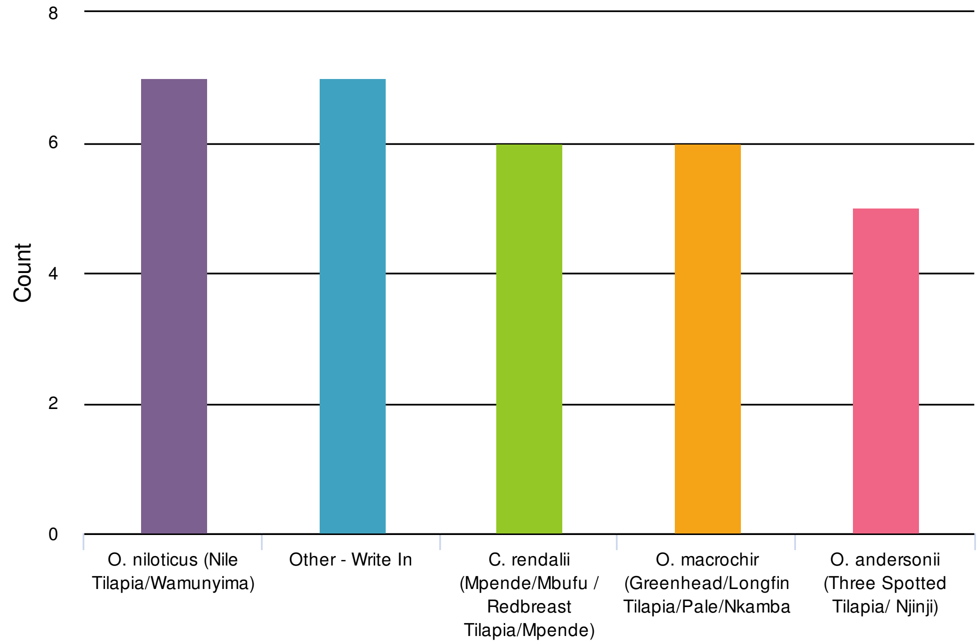
4. What is the main type of fish you currently produce in your operation?



Value		Percent	Responses
O. andersonii (Three Spotted Tilapia/ Njinji)		50.0%	27
O. niloticus (Nile Tilapia/Wamunyima)		22.2%	12
C. rendalii (Mpende/Mbufu / Redbreast Tilapia/Mpende)		9.3%	5
O. macrochir (Greenhead/Longfin Tilapia/Pale/Nkamba		14.8%	8
O. tanganice (ifilongo)		1.9%	1
Other - Write In		1.9%	1
			Totals: 54

Other - Write In	Count
Never%20produced%20before%20	1
Totals	1

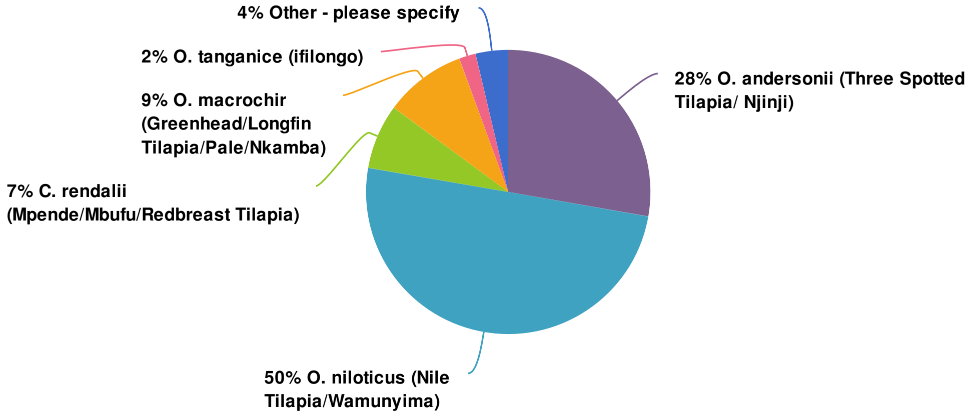
5. Any other type of fish you currently produce in your operation?



Value	Percent	Responses
O. niloticus (Nile Tilapia/Wamunyima)	25.9%	7
Other - Write In	25.9%	7
C. rendalii (Mpende/Mbufu / Redbreast Tilapia/Mpende)	22.2%	6
O. macrochir (Greenhead/Longfin Tilapia/Pale/Nkamba	22.2%	6
O. andersonii (Three Spotted Tilapia/ Njinji)	18.5%	5

Other - Write In	Count
None	3
Cat Fish	1
Cat fish	1
Catfish	1
Clarius gariepinus	1
Totals	7

6. What do you view as the most important species to Zambian aquaculture?



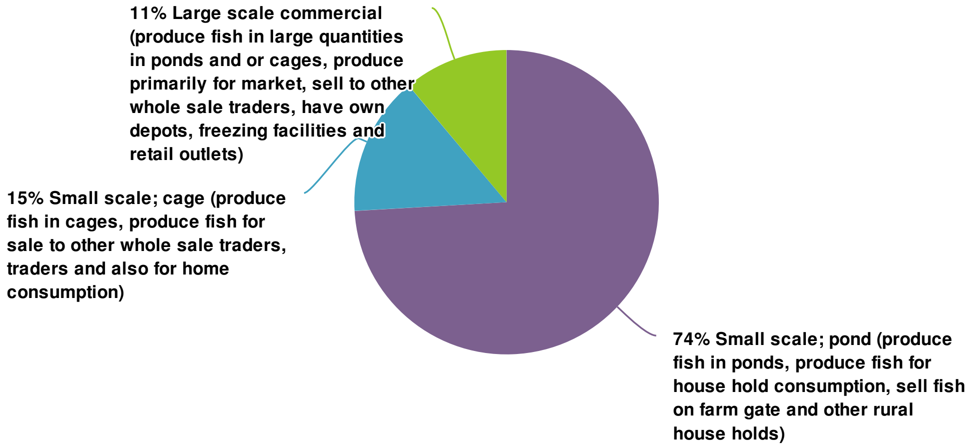
Value		Percent	Responses
O. andersonii (Three Spotted Tilapia/ Njinji)		27.8%	15
O. niloticus (Nile Tilapia/Wamunyima)		50.0%	27
C. rendalii (Mpende/Mbufu/Redbreast Tilapia)		7.4%	4
O. macrochir (Greenhead/Longfin Tilapia/Pale/Nkamba)		9.3%	5
O. tanganice (ifilongo)		1.9%	1
Other - please specify		3.7%	2
			Totals: 54

Other - please specify	Count
Don%27t%20know%20	1
I have no idea or experience with other species	1
Totals	2

7. Have you farmed O. andersonii (Three Spotted Tilapia/Njinji) in the past?

Value	Percent	Responses
Yes	64.8%	35
No	35.2%	19
		Totals: 54

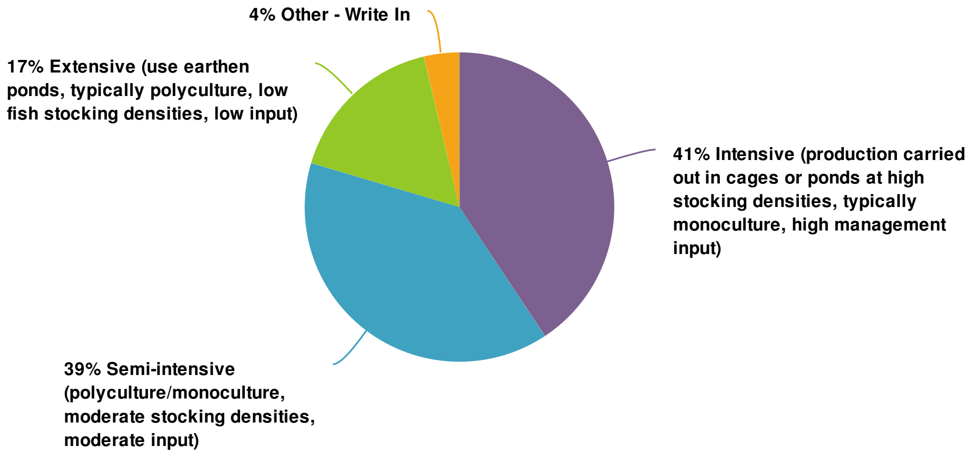
8. What scale of production operation do you run?



Value	Percent	Responses
Small scale; pond (produce fish in ponds, produce fish for house hold consumption, sell fish on farm gate and other rural house holds)	74.1%	40
Small scale; cage (produce fish in cages, produce fish for sale to other whole sale traders, traders and also for home consumption)	14.8%	8
Large scale commercial (produce fish in large quantities in ponds and or cages, produce primarily for market, sell to other whole sale traders, have own depots, freezing facilities and retail outlets)	11.1%	6

Totals: 54

9. What level of production intensity do you run on your farm?

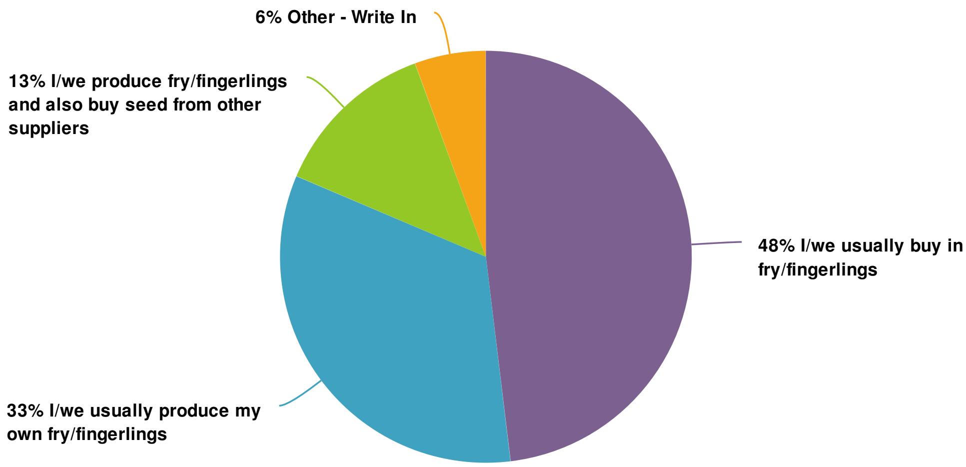


Value		Percent	Responses
Intensive (production carried out in cages or ponds at high stocking densities, typically monoculture, high management input)		40.7%	22
Semi-intensive (polyculture/monoculture, moderate stocking densities, moderate input)		38.9%	21
Extensive (use earthen ponds, typically polyculture, low fish stocking densities, low input)		16.7%	9
Other - Write In		3.7%	2

Totals: 54

Other - Write In	Count
Totals	0

10. How do you usually source seed (fry/fingerlings) for your operation?

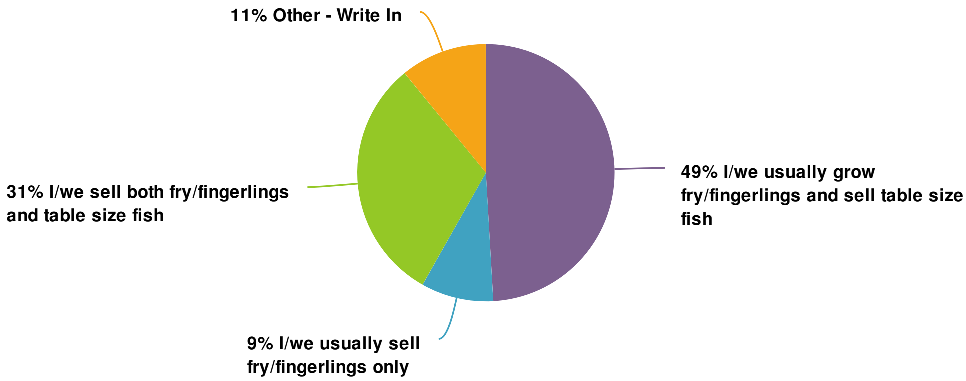


Value	Percent	Responses
I/we usually buy in fry/fingerlings	48.1%	26
I/we usually produce my own fry/fingerlings	33.3%	18
I/we produce fry/fingerlings and also buy seed from other suppliers	13.0%	7
Other - Write In	5.6%	3

Totals: 54

Other - Write In	Count
Source from the wild	1
We produce fingerlings for sale	1
Totals	2

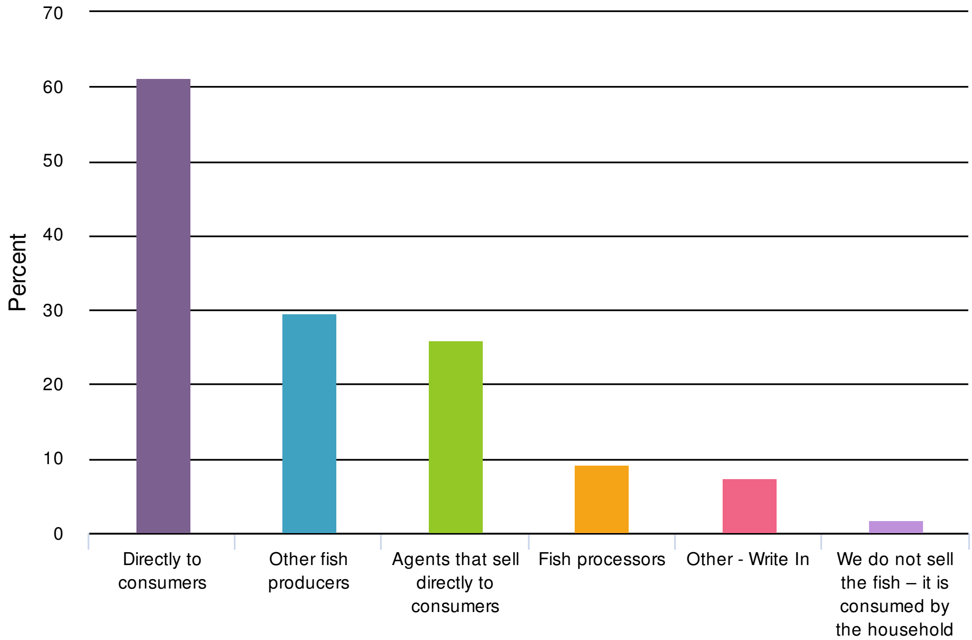
11. What is the main size of fish you sell?



Value	Percent	Responses
I/we usually grow fry/fingerlings and sell table size fish	49.1%	27
I/we usually sell fry/fingerlings only	9.1%	5
I/we sell both fry/fingerlings and table size fish	30.9%	17
Other - Write In	10.9%	6
		Totals: 55

Other - Write In	Count
Broodstock	1
I have never sold before because the previous bunch was poisoned	1
Table size fish	1
Table size only	1
Totals	4

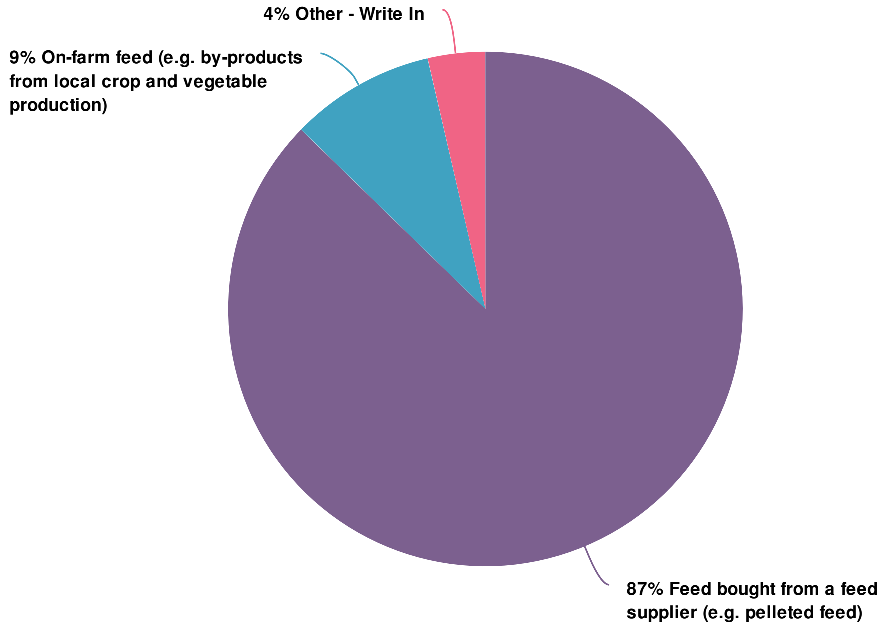
12. Who do you sell the majority of your fish to?



Value	Percent	Responses
Directly to consumers	61.1%	33
Other fish producers	29.6%	16
Agents that sell directly to consumers	25.9%	14
Fish processors	9.3%	5
Other - Write In	7.4%	4
We do not sell the fish – it is consumed by the household	1.9%	1

Other - Write In	Count
Did not sell any	1
Didn't sell	1
Fish Hatcheries	1
Totals	3

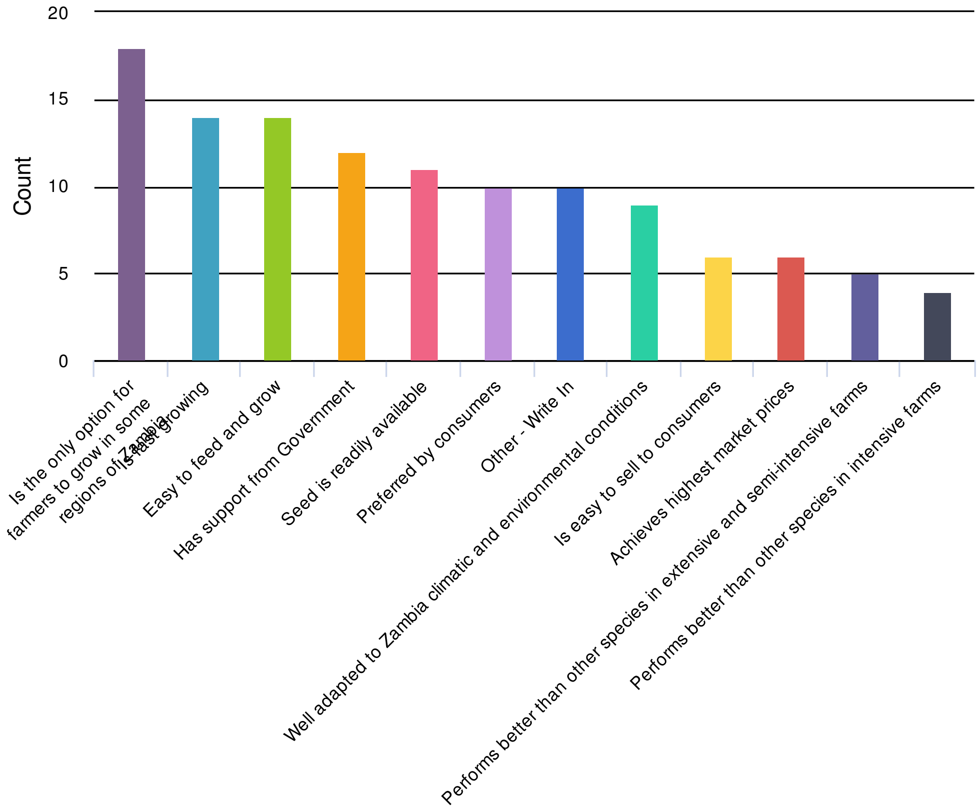
13. What is the main feed in your operation?



Value	Percent	Responses
Feed bought from a feed supplier (e.g. pelleted feed)	87.3%	48
On-farm feed (e.g. by-products from local crop and vegetable production)	9.1%	5
Other - Write In	3.6%	2
		Totals: 55

Other - Write In	Count
Combination Manure and Feed	1
Totals	1

14. How did you choose what type of fish to produce?



Value	Percent	Responses
Is the only option for farmers to grow in some regions of Zambia	32.7%	18
Is fast growing	25.5%	14
Easy to feed and grow	25.5%	14
Has support from Government	21.8%	12
Seed is readily available	20.0%	11
Preferred by consumers	18.2%	10
Other - Write In	18.2%	10
Well adapted to Zambia climatic and environmental conditions	16.4%	9
Is easy to sell to consumers	10.9%	6
Achieves highest market prices	10.9%	6
Performs better than other species in extensive and semi-intensive farms	9.1%	5
Performs better than other species in intensive farms	7.3%	4

Other - Write In	Count
Fisheries officer recommendation	1
It has a slow growth rate	1
It was recommended by someone from the government	1
It was the available	1
Just try and error	1
Resistance to diseases	1
Specific%252520directive%252520from%252520the%252520government%252520	1
Still%20new%20and%20had%20no%20option%20but%20recommended%20by%20the%20government%20	1
Was%25252520trained%25252520on%25252520the%25252520species	1
Totals	9

15. What is your perception of Three Spotted Tilapia (Njinji)?

	Strongly disagree	Disagree	Slightly agree	Agree	Strongly agree	Responses
Performs better than other species in extensive and semi-intensive farms Count Row %	8 19.5%	7 17.1%	8 19.5%	12 29.3%	6 14.6%	41
Performs better than other species in intensive farms Count Row %	7 17.1%	8 19.5%	9 22.0%	12 29.3%	5 12.2%	41
Is fast growing Count Row %	5 12.2%	10 24.4%	9 22.0%	12 29.3%	5 12.2%	41
Is easy to sell to consumers Count Row %	1 2.5%	1 2.5%	8 20.0%	16 40.0%	14 35.0%	40
Achieves highest market prices Count Row %	2 5.1%	10 25.6%	11 28.2%	9 23.1%	7 17.9%	39
Is the only option for farmers to grow in some regions of Zambia Count Row %	4 10.0%	10 25.0%	0 0.0%	9 22.5%	17 42.5%	40
Has support from Government Count Row %	2 5.0%	0 0.0%	3 7.5%	16 40.0%	19 47.5%	40
Easy to feed and grow Count Row %	4 10.3%	5 12.8%	8 20.5%	17 43.6%	5 12.8%	39
Well adapted to Zambia climatic and environmental conditions Count Row %	1 2.4%	4 9.8%	11 26.8%	15 36.6%	10 24.4%	41
Seed is readily available Count Row %	7 17.5%	11 27.5%	6 15.0%	9 22.5%	7 17.5%	40
Preferred by consumers Count Row %	0 0.0%	2 4.9%	17 41.5%	13 31.7%	9 22.0%	41

	Strongly disagree	Disagree	Slightly agree	Agree	Strongly agree	Responses
Growth in the cold months:What is your perception of ***Three Spotted Tilapia (Njinji)***? Count Row %	0 0.0%	0 0.0%	0 0.0%	1 100.0%	0 0.0%	1
Needs shallow ponds rather deep ponds:What is your perception of ***Three Spotted Tilapia (Njinji)***? Count Row %	0 0.0%	0 0.0%	0 0.0%	0 0.0%	1 100.0%	1
They breed even when they are small :What is your perception of ***Three Spotted Tilapia (Njinji)***? Count Row %	0 0.0%	0 0.0%	0 0.0%	0 0.0%	1 100.0%	1
Totals Total Responses						41

16. What presents the biggest challenge/barrier to the development of aquaculture in Zambia?

	Strongly disagree	Disagree	Slightly agree	Agree	Strongly agree	Responses
There are issues relating to access to land/water for aquaculture production in Zambia Count Row %	16 30.8%	11 21.2%	4 7.7%	10 19.2%	11 21.2%	52
Some aquaculture species are not allowed to be farmed in my region, or other regions Count Row %	7 13.7%	8 15.7%	4 7.8%	7 13.7%	25 49.0%	51
There is not enough access to technical expertise, support, and finance Count Row %	0 0.0%	5 9.6%	4 7.7%	13 25.0%	30 57.7%	52
I find it difficult to access skilled and semi-skilled labour Count Row %	6 11.8%	10 19.6%	7 13.7%	18 35.3%	10 19.6%	51
There are issues sourcing good quality seed Count Row %	3 6.0%	7 14.0%	4 8.0%	13 26.0%	23 46.0%	50
Challenges with distribution, logistics, and limited availability make it difficult to access quality seed (fry/fingerlings) Count Row %	5 9.8%	6 11.8%	5 9.8%	14 27.5%	21 41.2%	51
The cost of good quality seed (fry/fingerlings) is too high Count Row %	5 10.0%	14 28.0%	10 20.0%	7 14.0%	14 28.0%	50
The cost of good quality fish feed is too high Count Row %	1 2.0%	1 2.0%	2 3.9%	8 15.7%	39 76.5%	51
The price I receive for selling my final fish product is too low Count Row %	8 17.0%	9 19.1%	7 14.9%	6 12.8%	17 36.2%	47

	Strongly disagree	Disagree	Slightly agree	Agree	Strongly agree	Responses
I cannot compete with the prices of imported fish products Count Row %	10 20.4%	9 18.4%	8 16.3%	7 14.3%	15 30.6%	49
It is difficult to access markets to deliver fish for sale Count Row %	15 30.0%	18 36.0%	4 8.0%	4 8.0%	9 18.0%	50
There are too many government regulations involved in aquaculture production Count Row %	11 21.6%	15 29.4%	8 15.7%	3 5.9%	14 27.5%	51
Access to medicine and chemicals Count Row %	0 0.0%	0 0.0%	0 0.0%	0 0.0%	1 100.0%	1
Cost of getting licenses Count Row %	0 0.0%	0 0.0%	0 0.0%	0 0.0%	1 100.0%	1
HIGH cost of feed Count Row %	0 0.0%	0 0.0%	0 0.0%	1 100.0%	0 0.0%	1
Ignorance of the farmer. Count Row %	0 0.0%	0 0.0%	0 0.0%	1 100.0%	0 0.0%	1
Lack of patrols around the cages Count Row %	0 0.0%	0 0.0%	0 0.0%	0 0.0%	1 100.0%	1
The supply of the feed is our biggest challenge because it's very far Count Row %	0 0.0%	0 0.0%	0 0.0%	0 0.0%	1 100.0%	1
Theft of fish Count Row %	0 0.0%	0 0.0%	0 0.0%	0 0.0%	1 100.0%	1
Transportation cost Count Row %	0 0.0%	0 0.0%	0 0.0%	0 0.0%	1 100.0%	1
Totals Total Responses						52

17. Do you believe the industry is constrained by access to seed (fry/fingerlings) for fish production in Zambia?

Value		Percent	Responses
Yes		74.5%	38
No		17.6%	9
Maybe		7.8%	4

Totals: 51

18. Is O. andersonii (Njinji) constrained by access to seed (fry/fingerlings) for fish production in Zambia?

Value	Percent	Responses
Yes	73.3%	33
No	17.8%	8
Maybe	8.9%	4

Totals: 45

19. Please indicate how much you agree with the following statements regarding access to seed

	Strongly disagree	Disagree	Slightly agree	Agree	Strongly agree	Responses
There is adequate seed available and accessible for aquaculture production in Zambia Count Row %	17 34.7%	16 32.7%	8 16.3%	4 8.2%	4 8.2%	49
There are enough hatcheries supplying seed for aquaculture production in Zambia Count Row %	24 47.1%	17 33.3%	1 2.0%	6 11.8%	3 5.9%	51
There is a need for local nurseries to facilitate access to good quality seed in all regions Count Row %	1 2.0%	4 8.0%	2 4.0%	14 28.0%	29 58.0%	50
There is not enough access to technical expertise, support, and finance Count Row %	2 3.9%	4 7.8%	5 9.8%	15 29.4%	25 49.0%	51
Commercial hatcheries and nurseries are better sources of seed compared to government hatcheries and nurseries Count Row %	2 4.0%	4 8.0%	18 36.0%	14 28.0%	12 24.0%	50
Improved seed will support both small-holder and large-scale commercial aquaculture production in Zambia Count Row %	0 0.0%	1 2.0%	3 6.0%	12 24.0%	34 68.0%	50
Supply of improved *O. andersonii* (Three Spotted Tilapia/ Njinji) seed should be prioritised to help development of aquaculture production in Zambia Count Row %	3 6.5%	3 6.5%	6 13.0%	15 32.6%	19 41.3%	46
Allow production of O.niloticus is all corners of the country Count Row %	0 0.0%	0 0.0%	0 0.0%	0 0.0%	1 100.0%	1

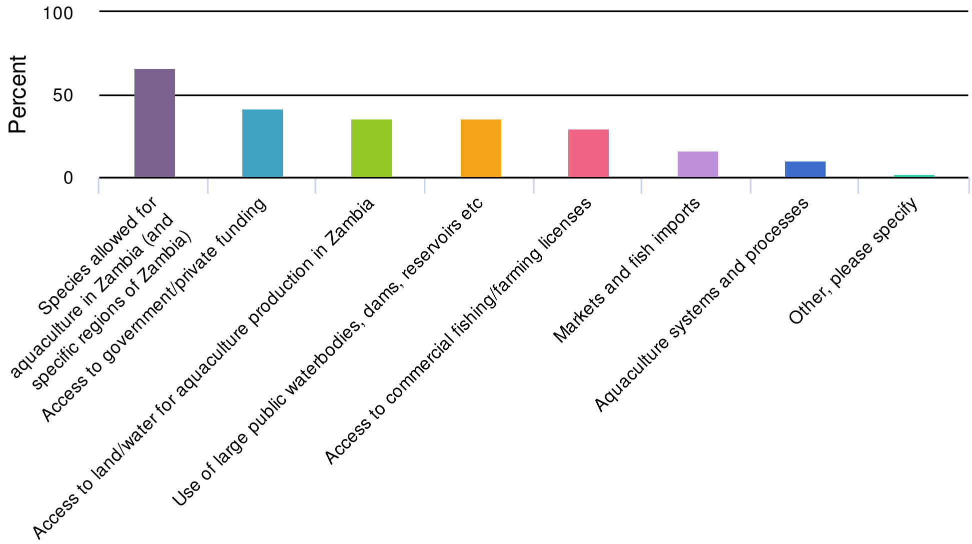
	Strongly disagree	Disagree	Slightly agree	Agree	Strongly agree	Responses
Totals Total Responses						51

20. Which opportunities have the greatest potential to increase production from the aquaculture industry in Zambia?

	Strongly disagree	Disagree	Slightly agree	Agree	Strongly agree	Responses
Improved access to land/water for development of aquaculture sites Count Row %	7 13.5%	6 11.5%	6 11.5%	14 26.9%	19 36.5%	52
Adoption of more intensive aquaculture systems (e.g. cage culture) Count Row %	8 15.7%	5 9.8%	5 9.8%	17 33.3%	16 31.4%	51
Increased production via availability of better seed Count Row %	0 0.0%	0 0.0%	4 7.7%	13 25.0%	35 67.3%	52
Increased production via availability of better feed Count Row %	0 0.0%	1 1.9%	1 1.9%	11 21.2%	39 75.0%	52
Increased production via the adoption of improved management practices Count Row %	0 0.0%	0 0.0%	7 13.5%	18 34.6%	27 51.9%	52
Declining output from capture fisheries Count Row %	1 2.0%	4 8.0%	12 24.0%	8 16.0%	25 50.0%	50
Growing demand from local consumers Count Row %	1 1.9%	2 3.8%	3 5.8%	19 36.5%	27 51.9%	52
Development of export markets Count Row %	0 0.0%	4 7.8%	2 3.9%	14 27.5%	31 60.8%	51
Development of processing capacity and opportunities to value addition Count Row %	0 0.0%	2 3.8%	3 5.8%	12 23.1%	35 67.3%	52
Improved access to finance and grants Count Row %	0 0.0%	1 1.9%	0 0.0%	5 9.6%	46 88.5%	52

	Strongly disagree	Disagree	Slightly agree	Agree	Strongly agree	Responses
Change the poan terms for farmer Count Row %	 0 0.0%	 0 0.0%	 0 0.0%	 0 0.0%	 1 100.0%	 1
More training Count Row %	 0 0.0%	 0 0.0%	 0 0.0%	 1 100.0%	 0 0.0%	 1
Training for small-scale farmers Count Row %	 0 0.0%	 0 0.0%	 0 0.0%	 0 0.0%	 1 100.0%	 1
Totals Total Responses						 52

21. Which areas are strongly regulated by Government policy and regulations?



Value	Percent	Responses
Species allowed for aquaculture in Zambia (and specific regions of Zambia)	66.0%	33
Access to government/private funding	42.0%	21
Access to land/water for aquaculture production in Zambia	36.0%	18
Use of large public waterbodies, dams, reservoirs etc	36.0%	18
Access to commercial fishing/farming licenses	30.0%	15
Markets and fish imports	16.0%	8
Aquaculture systems and processes	10.0%	5
Other, please specify	2.0%	1

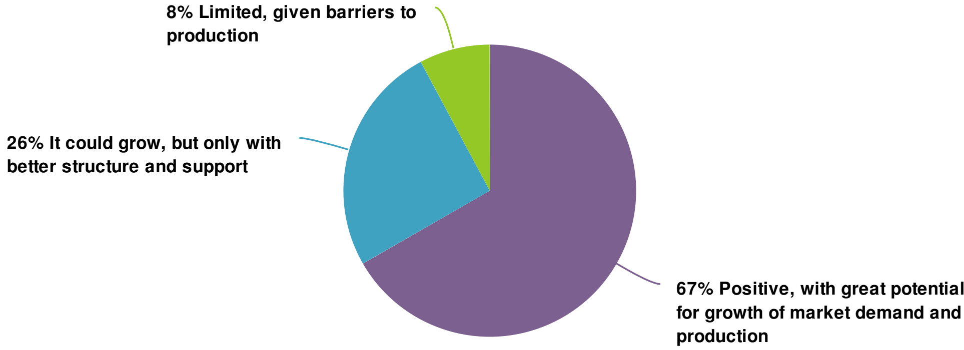
Other, please specify	Count
Sourcing of fish	1
Totals	1

22. What interventions could the Government make to support the growth and development of the industry?

	Strongly disagree	Disagree	Slightly agree	Agree	Strongly agree	Responses
Make it easier to obtain aquaculture licenses Count Row %	4 7.8%	2 3.9%	7 13.7%	18 35.3%	20 39.2%	51
Make it easier to access aquaculture sites in major reservoirs and water bodies Count Row %	3 6.0%	2 4.0%	5 10.0%	14 28.0%	26 52.0%	50
Reinforce geographic restrictions on the use of specific fish species Count Row %	13 25.0%	2 3.8%	10 19.2%	8 15.4%	19 36.5%	52
Invest in the delivery of technical support and advisory services Count Row %	0 0.0%	1 1.9%	2 3.8%	13 25.0%	36 69.2%	52
Provide grants or access to finance to support development of aquaculture projects Count Row %	0 0.0%	0 0.0%	0 0.0%	7 13.7%	44 86.3%	51
Improve the collection and reporting of market and pricing data Count Row %	0 0.0%	3 6.0%	7 14.0%	11 22.0%	29 58.0%	50
Improve the collection and reporting of industry production statistics Count Row %	0 0.0%	0 0.0%	13 25.0%	13 25.0%	26 50.0%	52
Support the development of infrastructure to improve market access Count Row %	0 0.0%	0 0.0%	3 5.9%	15 29.4%	33 64.7%	51
Restrict volumes of imported fish products to improve prices for local fish Count Row %	3 5.8%	5 9.6%	4 7.7%	8 15.4%	32 61.5%	52

	Strongly disagree	Disagree	Slightly agree	Agree	Strongly agree	Responses
Support development of hatcheries and breeding programs to improve seed/fingerling supply Count Row %	0 0.0%	1 1.9%	1 1.9%	10 19.2%	40 76.9%	52
Fish market for fish farmers Count Row %	0 0.0%	0 0.0%	0 0.0%	0 0.0%	1 100.0%	1
We need government to help with wire fence to protect ponds from predator Count Row %	0 0.0%	0 0.0%	0 0.0%	0 0.0%	1 100.0%	1
Totals Total Responses						52

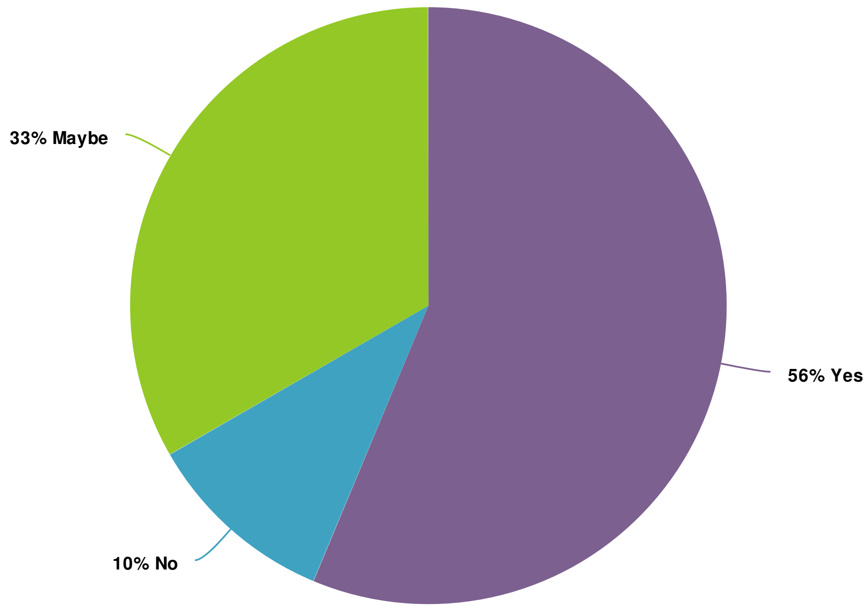
23. What do you believe to be the outlook for the aquaculture industry in Zambia?



Value	Percent	Responses
Positive, with great potential for growth of market demand and production	66.7%	34
It could grow, but only with better structure and support	25.5%	13
Limited, given barriers to production	7.8%	4

Totals: 51

24. Do you believe that O.andersonii (Three Spotted Tilapia/Njini) will be important for development of aquaculture production in Zambia going forward?



Value	Percent	Responses
Yes	56.3%	27
No	10.4%	5
Maybe	33.3%	16

Totals: 48

25. Why did you choose your response above?

Count	Response
2	The growth rate is very low and if it could be improved
1	According to my experience, O.niloticus performs better that O.andersonii.
1	Andersonii performs far much better than O.machoir because of the of it's growth rate buy still not better than O.niloticus
1	BECAUSE ITS THE NEXT BEST BREED COMPARED TO NILOTICUS.
1	Because it does not grow very big
1	Because it fast and big and adapt to the climatic conditions
1	Because it has given us excellent results that are sometimes better than the assumed superior species Niloticus.
1	Because it is indigenous and well adapted to the climatic conditions
1	Because most of the regions are farming this seed
1	Because of they are not complicated to handle and growth rate is very good
1	Better suited to marginal temperature conditions
1	Doesn't grow well and they are very small compared to O.niloticus
1	For business I would choose O.niloticus and ministry of fisheries can focus on O.andersonaii
1	Have never farmed O.andersonaii before so have no idea
1	I am a new farmer and I have never farmed O.andersonaii before
1	I am not sure of the species because I do not culture it. However, I have heard that it does perform well.
1	I do not know the species
1	If it can be improved like o.niloticus
1	It depends with location depending on the availability of funds, water and other resources
1	It doesn't grow fast
1	It doesn't grow fast as compared to Niloticus
1	It grows and performs better than local species
1	It has good growth as compared to local species
1	It has the potential to perform better.
1	It is better adapted to some parts of Zambia.

Count	Response
1	It is highly on demand and people like it
1	It thrives in the wild and thus well adapted to the local environmental conditions. Some studies have shown that it can perform better in lower temperatures which makes it more suitable in cooler parts of the country unlike O. Niloticus. Continued efforts on broodstock development are required.
1	More research should be put into it. Information from other farmers suggest that O. niloticus performs better
1	Never heard anything about it
1	No idea
1	No idea or knowledge about that
1	O.andersonii does better among the indigenous species. It just requires high management levels
1	Prices of feed should be affordable. Availability of more hatcherries to supply Fingerlings to farmers. Financial support to small scale farmers must be provided.
1	Still new in the business and don't have much experience in aquaculture industry
1	That fish is readily accepted by consumer and grows better compared to some local breed.
1	The fish grows well and multiply fast.
1	There is no O.andersonaii in the province, hence doesn't have any knowledge on O.andersonaii
1	This is because the government is much got interest on it
1	Tilapia has a better taste and easy to grow
1	With Government input, there is potential for the above
1	With good marketing and technical support the species can develop
1	Yes because it the only one species allowed in the region
1	andersonii show potential but cannot compete with Niloticus at this stage
1	depends on the location
1	if it can be developed it can become better especially on growth rate
1	if more farmers are encouraged to grow
1	it has got a high demand and is relatively easy to grow
1	its very shy especially when it is cold and too hot. It doesn't feed much

26. Which regions do you believe will have the most contribution/be most important to Zambian aquaculture going forward? Please rank the top 3

Item	Overall Rank	Rank Distribution	Score	No. of Rankings
Southern	1		287	30
Lusaka	2		231	24
Luapula	3		231	24
Northern	4		193	19
Copperbelt	5		159	16
Western	6		136	16
Central	7		86	9
Muchinga	8		66	7
North Western	9		62	6
Eastern	10		40	4
Other	11		11	1

Lowest Rank Highest Rank

27. If you have any additional comments, please leave them in the text box.

Count	Response
2	We need funding for business and development of the aquaculture
1	Allow farmers to farm O.niloticus and make funding more accessible
1	Get more women into aquaculture production because there more room despite the challenges
1	How can the government assist us support, specially with information and resources
1	I would like to appreciate for conducting the exercise. Fish farming is very expensive and we need grants
1	More efforts to be invested in trainings so as to encourage fish farming.
1	The farmers has never produced before and has limited knowledge about aquaculture
1	The worldfish program of training should be continued and most people are not trained in this region. I try to train farmers but they demand for lunch allowances so it becomes very hard for to conduct trainings and workshops
1	There is need for feedback session for whatever was achieved after the workshop or survey
1	There is need for grants to help farmers to expand and become commercial farmers
1	There is need for more sensitization on fish farming and funding.
1	We like to thank worldfish and the ministry. If there is any assistance%2C I will be very grateful
1	We need empowerment and the province doesn't have a hatchery or feed manufacture company. We need government intervention
1	We need solar panels for pumping water because diesel is very expensive
1	We need to be taught on how to produce fish so that we can commercialise and start exporting in future
1	We should continue engaging farmer's so that they are part of the survey
1	We would want to have more support for us to improve the industry
1	What is the government doing about the peace corps that were sent back due to covid-19
1	World fish should try to share information and train farmer's not only collecting information every year and no follow-ups
1	Would like to thank you for contacting the farmers considering that I am new and it shows that the government is very much concerned with farmers. We need skills and training for farmers to help with production.
1	You need to help farmers with more fish ponds and capital for continuous production

WorldFish

About WorldFish

WorldFish is an international, not-for-profit research organization that works to reduce hunger and poverty by improving fisheries and aquaculture. It collaborates with numerous international, regional and national partners to deliver transformational impacts to millions of people who depend on fish for food, nutrition and income in the developing world. Headquartered in Penang, Malaysia and with regional offices across Africa, Asia and the Pacific, WorldFish is a member of CGIAR, the world's largest global partnership on agriculture research and innovation for a food secure future.

For more information, please visit www.worldfishcenter.org

About AbacusBio

AbacusBio is a highly respected science and technology firm operating from offices in Dunedin and Rotorua New Zealand, and Edinburgh, United Kingdom. The firm delivers world class solutions for clients across the agribusiness world.

For more information, please visit www.abacusbio.com