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# Aquaculture in Zambia: An overview and evaluation of the sector's responsiveness to the needs of the poor

DEPARTMENT OF FISHERIES ZAMBIA

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# Aquaculture in Zambia: An overview and evaluation of the sector's responsiveness to the needs of the poor


## Authors
Sven Genschick, Alexander M. Kaminski, Alexander S. Kefi and Steven M. Cole



## Citation
This publication should be cited as: 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.

## Acknowledgments
This work was undertaken as part of the CGIAR Research Program on Fish Agrifood Systems (FISH). This is a joint publication between the Department of Fisheries in Zambia and WorldFish. Funding for this study was provided by the German Federal Ministry for Economic Cooperation and Development (BMZ) through the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ). A special thank to Dr. Mary Lundeba for her extensive knowledge on aquaculture in Zambia.

# Contents

# Introduction

Countries in Africa have been touted for their high aquaculture potential based on land and water availability, ideal temperatures and animal husbandry and agricultural practices (Brummet et al. 2008; Kaspetsky 1994; Aguilar-Manjarrez and Nath 1998). Increased production of farmed fish could help improve the food and nutrition insecurity situation in many of these countries and contribute positively to overall economic growth (Brummet and Williams 2000; Beveridge et al. 2010). Despite the potential, the development of aquaculture in most African countries has been sluggish compared to other regions, mostly because of weak infrastructure, markets, government policies and a lack of knowledge and skills to build the sector (Brummet et al. 2008). The total share of global production is still only 2.3%, with production in Egypt making up the bulk of the total output (FAO 2016). Recently, however, aquaculture production in sub-Saharan Africa has increased at an annual average growth rate of 12.6%, and there is evidence of commercial growth in certain countries such as Nigeria, Ghana, Uganda and Kenya.

A similarly positive trend can also be seen in Zambia, which has become the sixth-largest producer of farmed fish in Africa. In the 1980s, the farmed fish production was reported to be around 750 t, of which 86 t (11.5%) were produced by small-scale rural fish farmers, 94 t (12.5%) by government fish culture stations and 570 t (76%) by private larger-scale farmers (Mudenda 2009). By 2014, aquaculture in Zambia grew to a total output of 20,000 t, with three quarters of production coming from the commercial sector, namely intensive pond-based rearing units and cage culture. Zambia is the biggest producer of tilapia in the South African Development Community (SADC), and some of the largest freshwater commercial farms in Africa operate in Zambia (FAO 2016). The value chain is made up almost entirely of tilapia, and in recent times, there have been large investments made into the seed and feed sectors.

Much of the development of the small-scale sector in Zambia was and still is supported by national and international development programs (Mudenda 2009; Harrison 1996). While the promotion of aquaculture was prioritized for the small-scale sector through interventionist methods and to boost household fish consumption and food and nutrition security, new approaches today recognize the growing importance of promoting aquaculture as an enterprise. It is believed that pursuing aquaculture as a business would enable farmers to sustainably manage their systems for increased incomes (Edwards 2000).

In 2017, the African Development Bank (AfDB)[1] approved a loan for the Zambian government to implement the Zambia Aquaculture Enterprise Development Project (ZAEDP) to present the aquaculture subsector as a viable and inclusive business opportunity for small- to medium-sized farmers and enhance production and productivity for improved livelihoods along the aquaculture value chain. From an economic perspective, increased uptake of aquaculture by small-scale farmers could help increase per capita income, diversify livelihoods and combat poverty, as seen in the case of Ghana (Kassam 2013; Kassam and Dorward 2017). This is of critical importance given that in 2015, 54.4% of the population lived below the poverty line (76.6% in rural areas and 23.4% in urban areas) and 40.8% of people were considered extremely poor (CSO 2016).

Broadly, an increase in crop, livestock or fish production could result in more stable prices of these commodities (Haddad 2000) and, therefore, become more available and accessible for people who are not directly involved in production (Toufique and Belton 2014). A higher intake of fish, for example, can have a positive impact on human health as fish is not only rich in protein but also in fatty acids, micronutrients and vitamins, such as zinc, iron and calcium and vitamins A, B and B12 (Roos et al. 2006; Kawarazuka and Béné 2010; Zhao et al. 2016). Thus, from a health perspective, increased fish consumption among the poor could help reduce the high prevalence of chronic and acute malnutrition, which is particularly pertinent in Zambia, where 45% of children under 5 years of age are stunted, 15% are underweight and 6% are wasted (UNICEF 2013).

Given this wider context and the recent expansion and commercialization of aquaculture in Zambia, an important question that needs to be explored is how have the recent changes in the Zambian aquaculture sector contributed to the needs of the poor? The aim of this report is to (a) outline the current trajectory of aquaculture development in Zambia and (b) evaluate whether these development efforts are inclusive of and responsive to the needs of the poor.

# Analytical framework

Aquaculture is often promoted as one means of enabling small-scale farmers to improve their economic, food and nutrition security (Harrison 1996; Lewis 1997; Edwards 2000). Stevenson et al. (2009) attempted to systematically explore whether involvement in aquaculture is linked with poverty alleviation. In line with a range of research findings (Edwards 2000; Ahmed and Lorica 2002; Kassam 2013; Toufique and Belton 2014), participation in aquaculture by resource poor farmers derives benefits through "income", "employment" and "consumption" pathways. Beveridge et al. (2013) refer to the contribution of fish to improved household food and nutrition security of resource poor consumers as a function of increasing the availability of fish, people's access to fish and ensuring fish preferences are accommodated, all of which are important factors that must be considered in the production and sale of farmed fish products.

Figure 1 presents a schematic to further explain how aquaculture development efforts can help meet the needs of resource poor people, enabling them to benefit from their involvement in activities throughout the aquaculture value chain. There are many points of entry through which resource poor people can benefit from developments in the aquaculture sector. First, they can directly benefit through upstream or downstream activities in the value chain, i.e. through production or from postharvest activities. For instance, the increased production and sale of fish by large-scale farms/wholesalers could subsequently increase the supply of cheaper fish and create jobs (both formal and "informal"). In addition, larger-scale hatcheries, feed mills and other input suppliers could invest in improving the availability and quality of seed, feed and other aquaculture inputs (e.g. lime, cages, hapa material, etc.), thereby making it more feasible and less

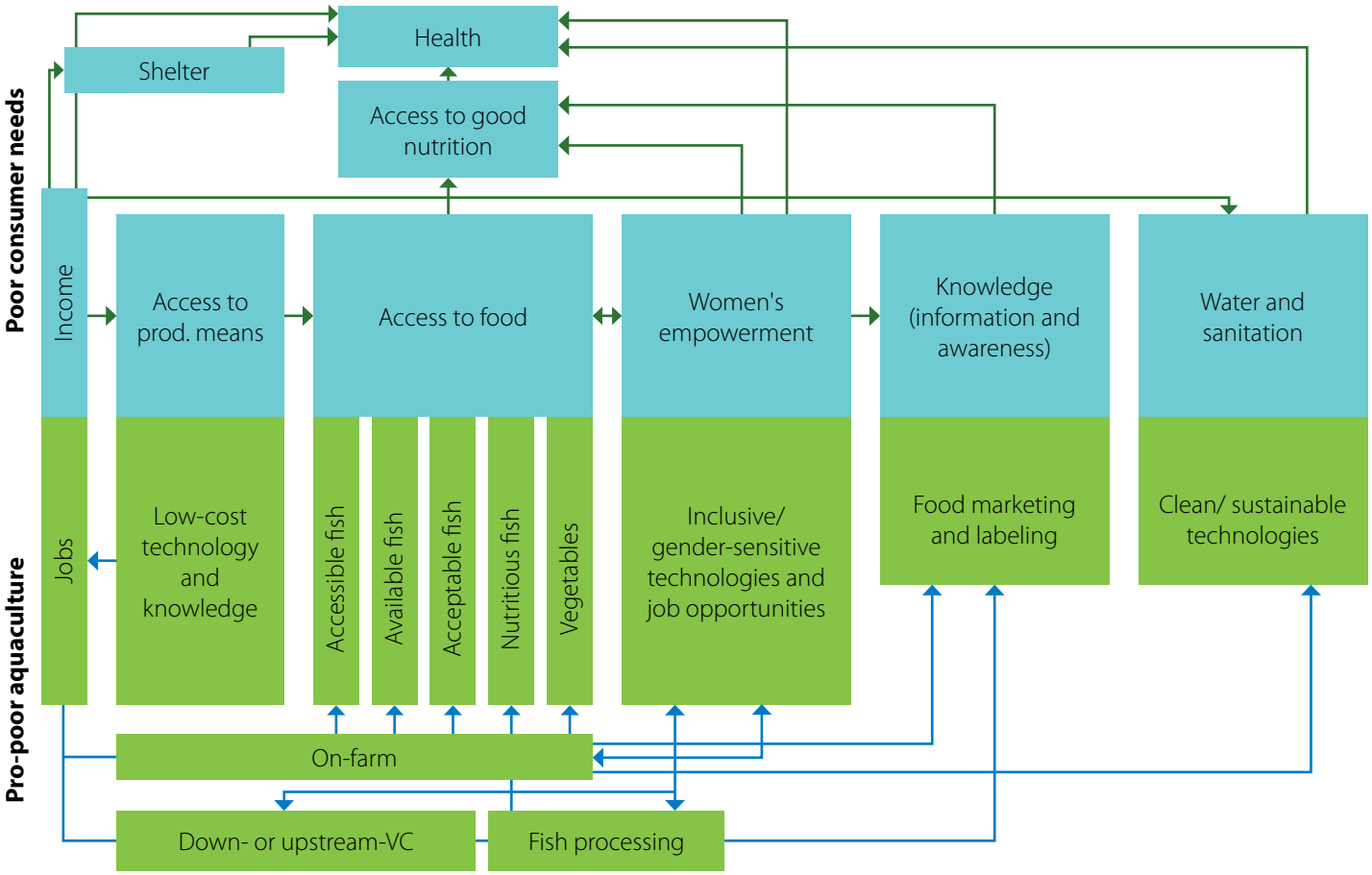



Figure 1. Pro-poor aquaculture framework (Genschick et al. in prep).

capital-intensive for small-scale farmers to get involved in production. Second, resource poor consumers can indirectly benefit from aquaculture development efforts by accessing fish that have been processed following improved food safety standards such as safer packaging with appropriate and easy-to-understand nutrition information. Growth in the aquaculture sector can also have significant impacts on women and youth empowerment outcomes, and in particular, increasing women's access to appropriate/lower-cost technologies or creating opportunities for youth to gain skills and knowledge by working as laborers on commercial farms. However, without direct policies and stakeholder involvement to ensure these benefits are realized, aquaculture development runs the risk of being highly exclusionary, especially in low-income settings (see Belton and Little 2011).

For this report, we use the framework above to evaluate Zambia's current aquaculture growth trajectory and especially its ability to provide direct benefits (e.g. increased incomes, employment opportunities and access to fish) to resource poor farmers and consumers. Secondary literature sources were reviewed, including government reports and the published scholarly and grey literature. Participant observation and years of experience working in the sector by the authors of this report were also drawn on to enrich the analysis and fill in some gaps when the secondary literature was unable to supply it. Given the relatively nascent state of aquaculture growth and development in Zambia, very little information or research on the indirect benefits of aquaculture exists in the secondary literature. Thus a key recommendation from our review suggests that more research is needed to adequately determine the overall benefits (both direct and indirect) that aquaculture development efforts have brought about, especially for resource poor farmers and consumers.


Small-scale farmer training at Misamfu Aquaculture Research Station, Kasama.

# Aquaculture sector overview in Zambia

A typology of aquaculture production systems used in Africa is differentiated by their extensive, semi-intensive and intensive nature, as seen in Table 1 (adapted from Hecht 2007). Systems fall between an extensive and intensive continuum based on the technologies, species and level of capital investment, labor and management practices they employ. These three systems exist in Zambia; however, the Zambian government characterizes them using a rather narrow typology, either as small-scale or large-scale production systems. This characterization creates a somewhat blurry line between extensive and intensive systems used by small- to medium-sized enterprises and fails to account for fish that is cultivated for subsistence versus commercial purposes.

During the years 2004–2014, the overall aquaculture production yield showed a positive upward trend in Zambia (Figure 2), almost doubling and thus providing an important source of fish that was traditionally only available from capture fisheries in Zambia. Small-scale aquaculture had, until recently, dominated the sector, though mostly for subsistence purposes with little impact on total fish supply for ordinary consumers. Today, the large-scale, commercial sector is rapidly expanding and overtaking the small-scale sector in total output providing hundreds of tons of fish weekly to consumers, albeit mostly in urban areas.

The rapid growth in the large-scale commercial sector is largely responsible for the increase in aquaculture production in the past few years. The sudden production increase from 12,988 t in 2012 to 20,271 t in 2013 was exclusively attributed to the expansion of entrepreneurial aquaculture, particularly in the cage-culture sector on Lake Kariba and from large-scale pond-based enterprises (DoF 2015). The relevance of the large-scale commercial sector is becoming even more apparent considering that the small-scale sector faced a 27% drop in production between 2011 (4060 t) and 2014 (2954 t) (DoF 2012 and 2015). Large-scale commercial aquaculture (land-based and cages) accounted for the largest contribution (71%) to the estimated overall aquaculture production in 2014, as

| Categories and Characteristics | Extensive | Semi-intensive | Intensive |
|---|---|---|---|
| Culture Systems | Earthen Ponds | Earthen ponds and cages | Cages, raceways, tanks and earthen/concrete ponds |
| Species | Polyculture (tilapia spp. catfish and/or wetland species) | Polyculture and/or monoculture (Tilapia and African Catfish or some monoculture (tilapia) | Mainly monoculture of tilapia, carp or catfish |
| Management input | Low to medium | Medium to high | High |
| Labor needs | Family labor to low requirement for external labor | Medium | Low to high (more capital intensive) |
| Capital costs | Low to medium | Medium | Medium to high |
| Operational costs | Zero to low | Medium | High |
| Business orientation | Low to medium | Medium to high | High |
| Integration with other farm activities | Medium to high | Low to high | Low |
| Feeding | Zero to supplementary, mostly through fertilization | Scheduled to unscheduled using mainly farm-made feeds | Scheduled intensive feeding using commercial feed or farm-made feeds |
| Fertilization | Zero to medium | Medium to high | Zero to high |
| Integration in value chain | Zero to medium, mostly isolated and little access to inputs and markets | Medium to high, access to inputs but little access to markets | High, key players in value chain |
| Socioeconomic characteristics | Mostly rural poor and subsistence-based | Rural to peri-urban, low to middle income households | Rural to urban, middle to high income, business owners |
| Level of commercialization | Household activity | Household to farm operation | Full commercial farm operation and business |

Table 1. Typology of aquaculture production systems in Africa (adapted from Hecht 2007).

seen in Figure 2 (DoF 2015). Extensive systems, such as small-scale ponds and stocking small water bodies or dams, accounted for only 29% of total estimated production. This has been a remarkable shift in the source of production, whereby less than 10 years ago the small-scale sector was producing about 75% of total aquaculture production in Zambia.

## Extensive aquaculture systems

The small-scale sector can be defined as using a range of systems between extensive and semi-intensive, encompassing anything from rudimentary earthen pond systems that are extensive in nature (no intentional nutritional inputs to feed the system) to semi-intensive pond systems that—through fertilization and/or use of supplementary feed—provide a farmer with fish for household consumption and/or income (see Edwards and Demaine 1997 for a description of these types of systems). Productivity is generally low in such systems in Zambia, depending on farm byproducts and seasons, as farmers attempt to balance fish farming with crop and vegetable production and livestock rearing.

## Small-scale pond aquaculture

Estimates show that small-scale aquaculture is scattered throughout Zambia in all 10 provinces with a total of 12,010 farmers engaged in fish production in 2014. The largest numbers of small-scale farmers are found in Northern and North-Western Provinces (see Table 2), where, according to DoF statistics, farmers produce the highest output. The number of small-scale farmers in a province or district is attributed in part to the presence of the DoF and the availability of extension services and/or government-run aquaculture research stations that also act as the main source of seed in most provinces. Access to perennial sources of water also impacts the number of small-scale farmers in a given province or district. Small-scale aquaculture is more likely to be adopted based on the capacities of extension officers or development agencies to impart knowledge on how to farm fish rather than on the economic viability of engaging in aquaculture, such as whether or not output markets are accessible (Mudenda 2009).

While provinces like Northern or North-Western have higher total production as a result of the large number of farmers, farm productivity per hectare is higher in Lusaka, Luapala and Copperbelt provinces. The proximity to extension services and a multitude of private enterprise actors and service providers can better support the small-scale sector, especially in the more urbanized Lusaka and Copperbelt provinces. The close links to output markets around these provinces also favor the integration of small-scale farmers into formal market value chains. In Northern or Eastern Province where there are much smaller urban markets and a larger geographical spread between farmers, access to input and output markets is generally lower, and thus the farming landscape is made up of mostly rural, resource poor farmers producing for subsistence or basic incomes.

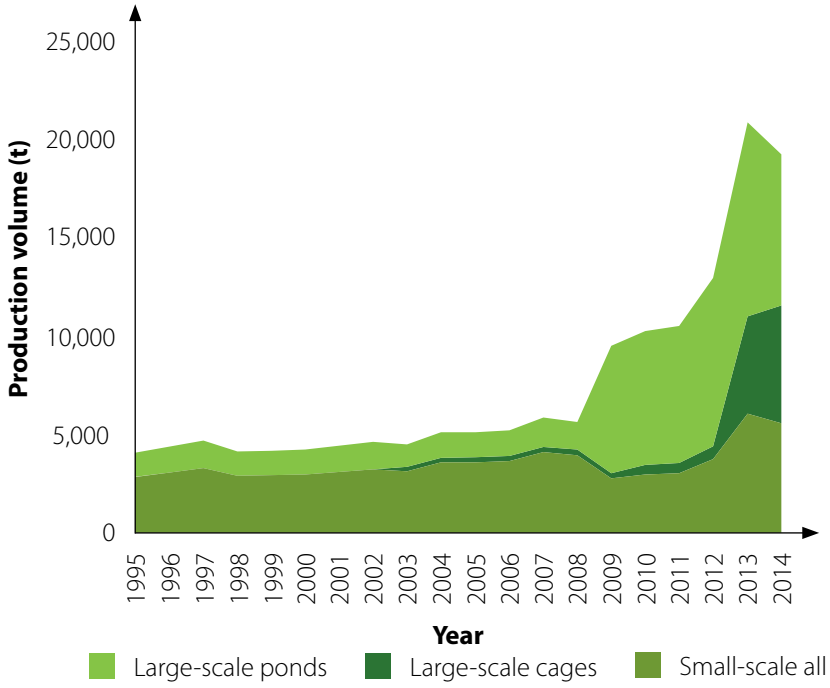



Figure 2. Fish output (t) by contribution from aquaculture and fisheries (2006–2014) (Kaminski et al. forthcoming).

As shown in Table 2, the overall output from small-scale aquaculture is estimated at 2,954 t from a total of 12,010 registered farmers in 2014. In comparison to previous years, it is evident that estimated output from small-scale aquaculture has declined strongly (27%), when production was estimated to be higher in 2010 (3985 t) and 2011 (4060 t).

A survey of farmers in Northern Province conducted by Nsonga (2015) found that most farmers were concerned about input and production constraints, such as inadequate quality of fingerlings, insufficient animal manure, lack of affordable fish feed, insufficient extension services and a lack of mobility to access markets from remote and often isolated pond sites. While numerous government policies and development agencies have attempted to develop and sustain the sector through extension projects, capacity building or the supply of inputs (fingerlings and feed), many projects have not made a significant impact developing the small-scale sector, mostly because of a lack of being able to provide sustainable options after the implementation phase. Musuksa and Musonda (2013) have found that a reliance on subsidized inputs without effective linkages to long-term government-run extension services fails to sustain the skills and inputs required to reach an optimal level of productivity in the rural fish-farming sector in Zambia. This is the case in other case studies across Africa (Brummet et al. 2008). With aquaculture being one of many farming activities for most small-scale farmers, and without the presence of a more integrated value chain with private actors (who can provide inputs and services), farmers tend to have low productivity or lose interest altogether and abandon their ponds (several fisheries officers in Northern Province personal communication, 2016).

The most recent estimations made by the DoF on small-scale aquaculture production for 2014 are based on four assumptions: (1) an average stocking density of 3 fish per $m^2$, (2) fish harvested at a weight of 250 g, (3) one production cycle per year for farmers and (4) a 10% mortality rate (DoF 2015). According to this formula, per ha productivity in small-scale aquaculture is estimated to be 6.75 t/ha. In accordance with the variation in the number of farmers per province, average farm productivity varies from 0.02 t to 0.79 t/ha with an average of 1.8 ponds per farmer, totaling an average of 230 $m^2$ (circa 23 x 10 m) that is under production (Table 2). The DoF acknowledges the limitations in collecting data from over 12,000 farmers countrywide, with limited funding and human resources. Subsistence farmers in impoverished areas are likely to be motivated by irregular and need-driven harvest regimes for consumption and immediate incomes, making the timing of data collection difficult as well. There are also no clear seasons in small-scale aquaculture with some farmers stocking ponds in the warmer months while others prefer to stock in the winter months when there are less crop and vegetable activities. Because of the absence of recordkeeping, funding, a lack of extension officers and accurate monitoring, an assessment of production output is very difficult to make (DoF 2015).

In a study with over 170 farmers in Northern Province, Nsonga (2015) found that small-scale farmers produce an average of 2 t/ha, while for North-Western Province, Simataa and Musuka (2013) found that 53% of small-scale farmers produce up to 1.5 t/ha, 37% produce between 1.6–4.5 t/ha and only 9% produce between 4.6–6 t/ha. It is worth noting that these productivity numbers were obtained from small-scale farmers in Zambia using a recall method and thus could be

| Province | No. fish farms | No. ponds | Facility area | Est. production (t) | t/ha | Mean prod. per farm (t) | No. ponds per farm | Mean size ponds |
|---|---|---|---|---|---|---|---|---|
| Central | 1,018 | 1,578 | 470,144 | 317.35 | 6.75 | 0.31 | 1.6 | 297.94 |
| Copperbelt | 1,203 | 2,732 | 706,866 | 477.13 | 6.75 | 0.40 | 2.3 | 258.74 |
| Eastern | 1,533 | 1,368 | 199,200 | 134.46 | 6.75 | 0.09 | 0.9 | 145.61 |
| Luapala | 485 | 1,761 | 262,273 | 177.03 | 6.75 | 0.37 | 3.6 | 148.93 |
| Lusaka | 282 | 646 | 328,128 | 221.49 | 6.75 | 0.79 | 2.3 | 507.94 |
| Muchinga | 1,573 | 2,265 | 44,055 | 29.74 | 6.75 | 0.02 | 1.4 | 19.45 |
| Northern | 2,436 | 4,940 | 1,180,794 | 797.04 | 6.75 | 0.33 | 2.0 | 239.03 |
| North-Western | 2,915 | 4,538 | 990,075 | 668.3 | 6.75 | 0.23 | 1.6 | 218.17 |
| Southern | 207 | 225 | 34,987 | 23.62 | 6.75 | 0.11 | 1.1 | 155.50 |
| Western | 358 | 506 | 159,854 | 107.9 | 6.75 | 0.30 | 1.4 | 315.92 |
| Total | 12,010 | 20,559 | 4,376,376 | 2,954.06 | 6.75 | 0.29 | 1.8 | 230.72 |

Table 2. Small-scale aquaculture production 2014 (DoF 2015).

severely low or inflated. It is worth noting that a range of productivity is expected for small-scale farmers, based on the typology presented in Table 1, where the sector runs along a spectrum from those who have access to few inputs and resources and therefore dig and manage ponds mostly for subsistence and household consumption, to those who have access to some services and inputs and attempt to target more formal markets. The SAAP (2014) report suggests that farmers with little or no inputs can reach an average productivity of 1.08 t/ha, while those having some limited access to inputs can reach an average of 3.1 t/ha. This suggests that an average productivity of 6.75 t/ha ascribed by the government to roughly 12,000 farmers in the country, and the total output from small-scale farmers, is probably an overestimation.[2]

## Intensive aquaculture

Intensive aquaculture is largely defined as entrepreneurial (commercial) farming in the form of diversifying cash crops by shifting some capital out of traditional agriculture to aquaculture (Brummet et al. 2008) or placing investments solely in different aquaculture technologies, most often in large-scale, land- and/or tank-based pond systems, raceways or cages in rivers and lakes. Large-scale aquaculture in Zambia has a relatively short history compared to extensive small-scale aquaculture. The colonial authorities of Northern Rhodesia (present-day Zambia) established two fish culture stations in the 1950s (Mudenda 2006). The Zambian government added several more fingerling production stations in the 1960s and 1970s that serviced a select few commercial farmers who grew fish using agricultural and livestock byproducts. It was not until the late 1980s and 1990s, after a few donor-supported development projects strived to increase the agricultural productivity of rural farmers, that the private sector started to take notice of the potential for fish farming, learning especially from their southern neighbor, Zimbabwe (Mudenda 2006). Today the commercial sector is largely located in the south of the country in Lusaka and Southern Provinces. Cage culture farming is situated mostly around Lake Kariba with large-scale intensive land-based enterprises located around the Kafue Flats. The majority of production from the commercial sector still comes from land-based pond operators, though cage culture is growing rapidly.

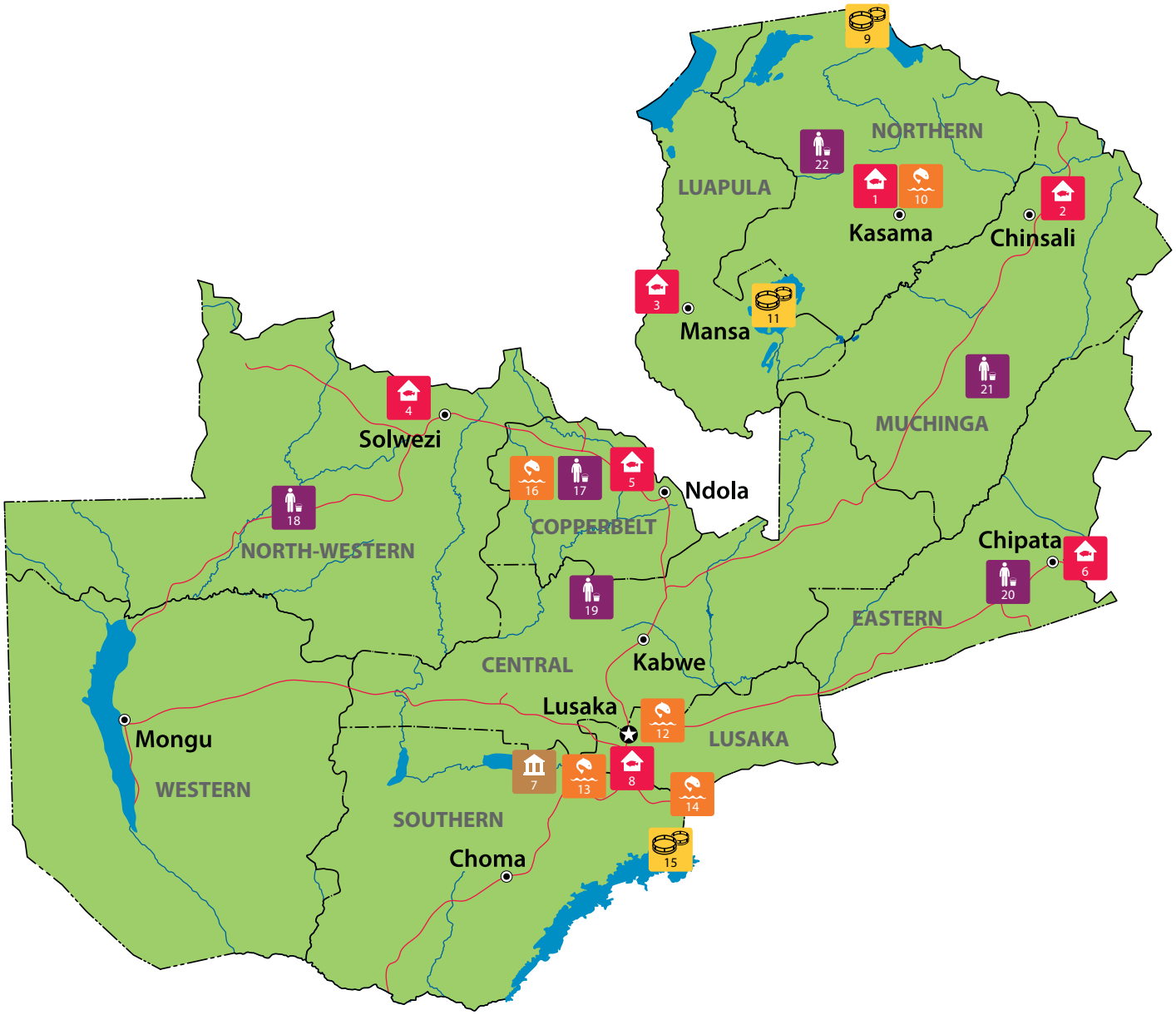
Some of the biggest land-based intensive fish farms today, such as Kafue Fisheries Ltd, started fish farming to recycle and use the metabolic waste from piggeries. Other farms, like Kalimba Farms, integrate crocodiles and tilapia production (Mudenda 2006; SAPP 2014).

In the 1990s, there were only three cages in Siavonga District in Lake Kariba. Aquaculture in the early 1990s was a fringe activity for most enterprises. On the other side of Lake Kariba, in Zimbabwe, cage culture had started growing rapidly in the 1990s with a total yield of 3500 t compared to Zambia's reported 30 t from cage culture (Halwart et al. 2007). By 1996, as little as 1500 t was being produced by the whole private sector in Zambia compared to an estimated 13,600 t in 2014. This translates to an annual growth of 11.56%, going from less than 5% of the total fish catch in Zambia (including capture fisheries) in the 1990s to more than 20% of the fish supply in 2014.

## Land-based commercial aquaculture

In 2014, there were over 20 intensive land-based commercial farmers in Zambia covering 216 ha countrywide. Land-based large-scale commercial farmers in Zambia are defined as those who employ intensive pond (or tank) culture, stocking mono-sex seed at higher stocking densities and who rely on the use of artificial feeds and make greater capital and labor investments. Intensive land-based systems include the construction of sophisticated earthen ponds and/or concrete or plastic water holding facilities. Production systems are usually distinguished in terms of size between 100 and 10,000 $m^2$ with a stocking density of around 3–5 fish per $m^2$ and a productivity of between 15–18 t/ha, with the average for commercial tilapia growth in Africa being around 16 t/ha (Jamu 2001).

In Zambia, aquaculture practices employed by large-scale commercial farmers vary, depending on stocking densities, tank or pond parameters and the types of species cultured. The use of artificial or organic fertilizers and feeds may differ as well. For the most part, however, there is a preference for monoculture of species with a few polyculture and shellfish enterprises existing as well. Generally, farmers of all sizes are legally permitted to farm Nile tilapia (*Oreochromis niloticus*) in certain areas of the country and only if permits are obtained. Farmers also cultivate local species such as the three-spotted bream (*Oreochromis andersonii*), the greenhead bream (*Oreochromis macrochir*), the redbreast bream (*Coptodon rendalli*) and the Tanganyika bream (*Oreochromis tanganicae*), with the majority growing these species because they are located in areas where the cultivation of *O. niloticus* is banned or because they are the only type of seed available, usually from government hatcheries. Given that most large-scale commercial farms are located in areas where the cultivation of *O. niloticus* is permitted, it can be argued that the policy might




1 Misamfu Research Station and hatchery

2 Chinsali Research Station and hatchery

3 Fiyongoli Research Station and hatchery

4 Solwezi Research Station and hatchery

5 Kitwe: National Aquaculture Research and Development Center (NARDC) and hatchery

6 Chipata Research Station and hatchery

7 Kasaka Fisheries Training Institute

8 Chiilanga Research Station and hatchery + DoF HQ

9 Lake Tanganyika: Commercial cage farming and large-scale land-based ponds and hatcheries using *O. tanganicae*

10 Kasama: One large-scale pond and raceway farmer and hatchery using *O. macrochir*

11 Chilubi (Lake Bangweulu): One commercial cage farmer using *O. macrochir*

12 Lusaka Province: Some medium-large scale land-based ponds and hatcheries using *O. niloticus* and *O. andersonii*

13 Kafue Flats: Large-scale commercial land-based ponds using *O. niloticus*

14 Chirundu: Commercial pond-based farms and hatcheries

15 Siavonga: Large-scale commercial cage farming and hatcheries using *O. niloticus*

16 Copperbelt Province: Large-scale pond producers and hatcheries using *O. niloticus* and *O. andersonii*

17 Copperbelt Province: >1200 small-scale farmers using *O. andersonii*, *O. niloticus*, *O. macrochic* and *T. rendalli*

18 North-West Province: >3000 small-scale farmers using *O. andersonii*, *O. niloticus*, *O. macrochir* and *T. rendalli*

19 Central Province: > 1000 small-scale farmers using *O. andersonii*

20 Eastern Province: >1500 small-scale farmers using *O. andersonii*

21 Muchinga Province: >1600 small-scale using *O. macrochir* and *T. rendalii*

22 Northern Province: >2500 small-scale farmers using *O. macrochir* and *O. tanganicae* and *T. rendalii*

Figure 3. Aquaculture landscape in Zambia.

discriminate against those farmers located outside the main output markets and who have less access to indigenous tilapia seed and commercial feeds, among other inputs (Simataa and Musuka 2013). The newly approved ZAEDP program run by the government in partnership with WorldFish aims to develop a genetic improvement program for *O. andersonii* to provide an improved strain of indigenous fish for farmers located outside of the *O. niloticus* zone.

Most commercial land-based pond farmers do not match the scale of production of Kafue Fisheries Ltd, which produces about 1500–2000 t per year at a rate of about 20–50 t per pond for each rearing cycle with two cycles every year. Land-based pond commercial fish farmers are mainly located in Lusaka (34%), Copperbelt (52%) and Southern provinces (11%), with the remainder located in Northern Province (4%). Currently, Kafue Fisheries Ltd is the largest land-based commercial fish producer in Africa, with a pond surface area of 100 ha, marketing an average of 4–6 t of fish daily. Other major fish farmers are Nsobe Farms in Ndola and Macademia Farms in Kitwe. There is also Kalimba Farms just outside Lusaka farming *O. andersonii*, Palabana Fisheries farming *O. niloticus* and *Cyprinus spp.*, Great Lake Products farming indigenous *O. tanganicae* in Mpulungu on the shores of Lake Tanganyika, Miracle Fisheries farming *O. Macrochir* just outside Kasama in Northern Province, a few farmers farming *O. niloticus* in Chirundu, Southern Province, on the Zambezi River (Chirundu Bream, Benzo Farm) and several medium-sized farmers in Solwezi, North-West Province and Copperbelt Province.

While the Food and Agricultural Organization (FAO) (2004) reported that there were about 20–24 large-scale commercial land-based farmers in 2004, Mudenda (2006) and Musuka and Musonda (2012) reported a decline to 11–15 farmers between 2006 and 2012 with the number of large-scale commercial farmers growing again to more than 20 in 2014. Musuka and Musonda (2012) reported that the decline can be attributed to a struggling economy during that period, a lack of government policy at the time, high credit loans, lack of availability in quality seed and feed, high environmental impact assessment (EIA) costs and red tape bureaucracy. Today, there is an increase in the amount of large-scale commercial land-based pond operators that is thought to exceed the amount presented in the 2015 DoF report. This points to commercial aquaculture in Zambia still being in a nascent stage whereby large-scale farmers are attempting to diversify their production by getting into fish farming. Almost all of the above farms have other agricultural activities, and investment in aquaculture was and still is seen as a risky venture. This might change, however, with the speed at which aquaculture is developing in Zambia, as this report reveals.

The introduction of two major cage culture operators in Siovonga between 2011 and 2013 created a sudden surge in large-scale commercial farming, with improved access to high quality feeds and seed as well as the introduction of a new aquaculture policy (Fisheries Act No. 22 of 2011) that provided enabling conditions for a sudden growth in the sector. At the same time, five new enterprises entered the intensive land-based aquaculture sector (Musuka and Musonda 2012). In 2014, intensive land-based farmers accounted for 51% of aquaculture production with 9805 t being produced, followed by cage culture enterprises accounting for 20% of the production. Together, the large-scale commercial sector accounts for 71% of the country's aquaculture production, which is a significant difference from 2009 when the commercial sector only produced 25% of the 5000 t produced that year (ACF/FSRP 2009). If the small-scale sector is indeed producing less than what is reported, then it is argued here that the vast majority of farmed fish produced in Zambia today is coming from the large-scale commercial sector.

## Cage aquaculture

On Lake Kariba, intensive cage fish farming was introduced in the late 1990s using *O. niloticus*. Today, there are more than 100 cages on Lake Kariba, up from only three in the late 1990s. Many operators still regard the high cost of formulated feeds, access to high quality seeds and the need for expensive EIAs as obstacles to the growth of the sector in Zambia. However, the introduction of two major companies, Kariba Harvest (a subsidiary of the Zimbabwean aquaculture giant Lake Harvest Ltd) and Yalelo in 2011, has transformed the sector. The latter injected USD 2.3 million and the former remains the biggest multinational cage culture producer in Africa. Together, they amount to 85% of total volume of cages on Lake Kariba in 2014. Lake Harvest Ltd alone produced about 2000 t of the 3805 t in 2014, and Yalelo aims to produce over 6000 t by the end of 2017.

The arrival of these two players has dramatically altered the value chain and established cage culture in Zambia with an estimated production going from only 30 t in the late 1990s up to an estimated 4000 t in 2015 (DoF 2015). This is expected to have increased to over 8000 t in 2017, though yet to be verified in government reports. The growth of the sector has led

some companies to expand, such as Yalelo investing in an out-grower scheme called Kambashi Fisheries in Chilubi on Lake Bangweulu (farming *O. macrochir*) in an effort to measure the viability of cage culture in other water bodies and expand the sector. Lake Kariba is not the only cage-culture site: Mpende Fisheries, located on the shores of Lake Tanganyika, produces around 200 t of *O. tanganicae* in cages every year. Lake Harvest Ltd operates its own hatchery and selective breeding facility and owns a state of the art processing plant in Zimbabwe, which produces fresh fillets for air shipment to high-end markets in Europe (Brummet et al. 2008). Lake Harvest Ltd in Zimbabwe exports tilapia to suppliers in South Africa, Zambia, Botswana, Malawi and even the UK, though sales to Europe only make up 5% of its total sales (Corsin et al. 2010). Prices in regional and domestic markets can now be higher than in Europe, and companies are focusing on marketing their products in Africa (Cocker 2014) with Kariba Harvest in Siavonga producing almost entirely for the Lusaka and Copperbelt provincial markets.

Intensive cage culture in other water bodies has yet to take off as it has in Siavonga, on Lake Kariba, and some major challenges including capital investment, infrastructure, breeding capabilities, proximity to larger urban markets and access to high quality feed and seed still inhibit expansion. In places such as Northern and Luapula provinces, the proximity to major capture fisheries such as Bangweulu, Tanganyika, Mweru and Mweru-Wantipa mean that cheaper wild fish is readily available to supply local markets. This combined with the recent introduction of cheap imports of Chinese tilapia make it difficult for small- and medium-scale enterprises (SMEs) to establish lucrative markets for locally produced farmed fish. This might be a further reason why the large-scale, commercial sector has yet to establish itself in these areas where cheaper imported fish seem to penetrate through the likes of extensive retail outlets such as those owned by Capital Fisheries Ltd, who import and distribute fish around the country. The proximity of places such as Lake Kariba to urban markets makes it more attractive for intensive aquaculture (and in particular cage culture), meaning that almost all production from cage culture comes from Southern Province.

Large-scale cage culture on Lake Kariba, Yalelo, Siavonga.

## Seed supply

### Hatcheries and farmer-to-farmer networks

Difficulties in accessing secure supplies of high quality feed and seed are often described as the biggest barriers to aquaculture development in Africa (Dey et al. 2006; Hecht 2006; Brummett et al. 2008; Beveridge et al. 2010). The fish seed supply sector in Zambia has experienced major changes over the past decade. In the past, there were only nine state hatcheries that supplied the entire aquaculture sector with mixed-sex tilapia fingerlings. Today, the growth of commercial aquaculture has seen large-scale aquaculture producers developing their own hatcheries that produce mixed-sex and male sex-reversed fingerlings for grow-out purposes. Through on-site hatchery production (a form of vertical integration), some large-scale producers have more control over costs, quality and continuity in supply by producing their own seed. This is a major trend for commercial operators in Zambia. The core business of a commercial operator is thus defined by the production of fry and fingerlings, either for their own grow-out or for selling to small- to medium-sized farmers, with most companies favoring the former, while only four operators have found niches in the latter. Palabana Fisheries has, for instance, begun supplying tilapia fingerlings (mostly *O. niloticus*) to small-scale farmers located in close proximity to the company through out-grower schemes that attempt to stimulate the small-scale sector. This out-grower scheme was tested and funded by the Swedish International Development Cooperation (SIDA) together with the FAO and International Labour Organization (ILO).[3]

There are six operating state-run hatcheries in the country that produce fingerlings primarily for small-scale aquaculture and stocking in small local water bodies. These hatcheries, however, only produced about 516,000 fingerlings in 2015 (mostly *O. macrochir*, *C. rendalli* and *O. andersonii*), which cannot possibly meet the fingerling demand of over 12,000 registered farmers around the country. To put this into context, Kafue Fisheries Ltd, one of the largest commercial land-based pond farms in Zambia, produces more than 2 million fingerlings every year. Most private hatcheries, so far, only supply for their own grow-out operations, and almost all of them are located in either Southern Province or in major cities such as Lusaka, Kitwe and Ndola. This means that most small-scale farmers in the country do not have access to fingerlings from private hatcheries and are largely dependent on state-run hatcheries that do not have the capacity to supply all registered small-scale farmers.

This was confirmed by a small-scale fish farm survey (Kaminski et al. In press) that attempted to uncover the main source of fingerlings of such farms in Northern Province. The same study also collected data on the fingerling sales from a state-run hatchery in the province to investigate where fingerlings were being sold and how they were being distributed. The results show that the main sources of fingerlings for small-

Photo credit: Chosa Mwemba/Worldfish

Hatchery producing native *O. tanganicae*, Great Lake Products Ltd, Mpulungu.

scale farmers in Northern Province are neighboring farmers (44% of respondents), development projects (24%), natural sources (16%), and directly from the state-run hatchery (15.4%), though almost all fingerlings (except those recruited from natural sources) originate from the state-run hatchery. This reveals the importance of farmer-to-farmer networks that supply farmers with seed from hatcheries, though it is unlikely that such networks match the level of development and sophistication seen in Asia, with farmers haphazardly recruiting fish from various sources. It is likely, and subsequently reported by DoF officers, that many of these fish are inbred and/or stunted as farmers attempt to satisfy their own seed demand by recycling their fish in their own ponds or from neighbors' ponds.

The state-run hatchery, Misamfu Aquaculture Research Station in Northern Province produced 1,062,314 fingerlings between 2005 and 2015—only half of what one large company such as Yalelo can produce in a year. Of these fingerlings, 54% were part of government-run programs to restock small water bodies and dams in the province over a 10-year period. The other 46% were distributed to small-scale farmers, 59% of which were bought by development organizations (e.g. World Vision, Caritas, Self Help Africa) for distribution in donor-driven, small-scale aquaculture projects. The DoF distributed the remaining fingerlings to small-scale farmers in the province over the same period (Kaminski et al. In press). The small-scale sector in Zambia has for decades been dependent on state-run hatcheries and extension services for inputs, which has so far resulted in little sustained growth.

Among surveyed small-scale farmers in the Kaminski et al. (In press) study in Northern Province, where the use of *O. niloticus* is banned, *C. rendalli* was the most commonly used seed (81% of surveyed farmers), followed by *O. macrochir* (30%) and *O. andersonii* (5%), with no farmers using *O. niloticus*. These trends vary from province to province where there may be more availability of *O. andersonii* or *O. macrochir*. There is some criticism that the ban gives farmers located in areas where it is not enforced an unfair advantage and further marginalizes small-scale farmers who reside in areas where it is enforced from accessing better performing strains of seed (Simataa and Musuka 2013). This surfaces an important debate on food supply, food and nutrition security and the conservation of biodiversity. This also points to a potential need for future investments in genetic enhancement of indigenous strains to meet the demands of farmers in areas where the *O. niloticus* ban applies and to satisfy environmental concerns.

## Feeds and fertilization

Feed is another important challenge facing the development and growth of aquaculture in Africa (Brummett et al. 2008; Gabriel et al. 2007; Hecht 2006, 2007) where it can account for over 60% of the total

Photo credit: Alexander Kaminski

Woman feeding fish in extensive pond system, Kawala, Mbala District.

costs of fish production (Jamu and Ayinla 2003). For decades, the small-scale sector in Zambia has attempted to feed and fertilize ponds in integrated systems using locally sourced materials (Bentley and Bentley 2005) promoted by government-run or donor-driven programs. Feeding/fertilization regimes in rural areas have not changed significantly and can be categorized according to three different technologies: fertilization/manuring, on-farm feed (using by-products from local crop and vegetable production) or pelleted commercial feed application. A combination of these regimes exists when access permits. A study conducted by Musuka and Mainza (2015) found that the majority of small-scale farmers are dependent on manure to fertilize ponds and nourish fish through a natural bloom of phytoplankton. This was confirmed by a farm survey (Kaminski et al. In press) where 25% of the surveyed farmers reported the use of pelleted commercial feed (77% of which was distributed by development projects), 11% used on-farm produced feeds (made from home-grown products) and all the farmers from the survey practiced fertilization using mostly compost and household or animal waste, which was the only source of pond nutrients for 75% of the farmers.

The growth of the commercial sector has started to stimulate the development of the feed sector. Numerous existing feed mills, such as Savanna Streams, Farm Feeds, Olympic Milling, Tiger Feeds, and Novatek Animal Feeds, invested into the development of aquafeeds over the last 5 years and started diversifying their product portfolio to satisfy the requirements and needs of large-scale commercial fish farms. Kaminski et al. (In press) estimated that these companies produced around 30,000 t of feed in 2015. Novatek Animal Feeds, for example, produces about 600–800 t of feed per month with four different product lines (fry mash, juvenile crumble, starter pellets and grower pellets), none of which existed on the market in Zambia before 2015. In anticipation of future aquaculture production expansion, large-scale commercial operators ventured into partnerships with feed mills to better control supply, quality and prices of feeds.

To date, however, almost all micro-ingredients, such as fishmeal, premixes and vitamins, are still being imported, which is keeping the price of commercial feeds relatively high in Zambia. This may contribute to why feed companies have yet to distribute aquafeeds to small-scale farmers around the country where there is little demand for expensive feed products (Kaminski et al. In press). Feed companies such as Novatek Animal Feeds have retail outlets all over the country and express the desire to distribute the product to small-scale farmers, though not until there is sufficient demand from the sector. Additionally, and according to local DoF extension officers, many small-scale farmers also do not know how to use commercial feeds, which hinders their ability to demand such products. This is expected to change, however, with the investment of two large, foreign-owned feed companies in Zambia in 2017. Aller Aqua has partnered with Yalelo, and Skretting with Lake Harvest Ltd to build two feed factories in Siavonga. This is envisaged to radically reshape the feed sector by the end of 2017 and provide an additional 75,000 t of aquafeed in the country. These large-scale producers have partnered with the international feed giants to secure a consistent source of cage feed for their own production and the feed companies in turn have seen an opportunity to expand the feed supply chain in the region. The Aller Aqua factory is expected to be the largest fish feed factory in Africa with an expected 50,000 t to be produced by the end of 2017. Personal communication with representatives from these companies suggest that Zambia aims to be an exporter of fish feeds to neighboring countries in the coming years.

## Markets and prices

Markets in the value chain differ across geographic locations, rural and urban areas, and wealth status of consumers. The pond-based, small-scale sector produces mainly for household consumption and local sales, but very rarely as a primary agricultural activity. The fish farm survey carried out by Kaminski et al. (In press) showed that 41% of surveyed farming households use most of the harvest for household consumption, 57% sell their harvest in local markets and 2% use their fish mainly for barter and trade. Other studies in Zambia also confirm that about 40% of fish farming households consume all of their fish and do not sell within local markets (Nsonga 2015; Musuka and Musonda 2013).

The Kaminski et al. (In press) study further shows that when small-scale farmers sell their fish, 64% sell their tilapia at pond site. Fish farmers use social institutions such as churches and community meetings as marketing strategies and communication channels to announce the harvest and sell directly from their farms. Some farmers use the local DoF extension officers to help sell their produce in local markets. The DoF officers can also sometimes secure customers from nearby towns to visit the farm (DoF officers, personal communication 2016). Almost one-third of farmers from the survey sold their fish in the village by going door-to-door. This highlights

the importance of local, "informal" markets for the small-scale sector. In most cases, farmers use a combination of these marketing strategies.

The majority of farmers from the same survey (94%) stated that their fish was sold at a higher price than fish from capture fisheries. The remainder was sold at the same price, and no fish from small-scale aquaculture was sold at a lower price than capture fisheries. Absolute fish prices were difficult to assess as fish was sold based on the species and the size of the fish, not by weight. Smaller fish (<100g) are usually sold in bundles that can consist of 10–30 fish while larger fish (>200g) are sold per single whole piece.

Large-scale commercial farms, meanwhile, mostly target urban areas as primary markets for selling fish to the middle and upper classes. Across the different operators, the majority of the overall production is transported to and sold in the capital, Lusaka, either through company-owned retail outlets, or wholesale depots. Some large-scale producers have their own ice production, freezing facilities and refrigerated trucks. Some actors operate with only one wholesale depot, while others directly engage with a small number of retailers, and one company (Lake Harvest Ltd.) distributes its produce to 27 wholesale depots in five provinces. Capital Fisheries Ltd is a major trader of wild, farmed and imported fish and also buys fish from small- to large-sized farms that do not engage in their own processing. Capital Fisheries Ltd is one of the only large-scale processors in the value chain that sells packaged gutted/scaled whole fish and a small percentage of packaged filleted tilapia.

According to Kaminski et al. (In press), the price of commercially farmed fish in Zambia is slightly higher than from capture fisheries, though this largely depends on fish size and is often subject to unpredictable price fluctuations. The latter are largely based on a volatile exchange market and an erratic capture fisheries supply. Generally, farmed fish from the commercial sector is categorized into three different grades: (1) grade 1 describes fish that weighs more than 300 g and is currently sold for ZMW 24–27 (USD 2.55) per kg; (2) grade 2 comprises fish that weighs 100 g to 250–300 g and is sold at ZMW 18 (USD 1.80) per kg; and (3) grade 3 is for fish that weighs less than 100 g and is sold at about ZMW 8 (USD 0.80) per kg. Products are sold whole in fresh or frozen form. Particularly interesting is the fact that grade 3 fish, which is not sold in formal supermarkets, is highly demanded by mostly female retailers who purchase fish from depots in Lusaka when it arrives together with the larger fish intended for formal retail. Personal communication with Kafue Fisheries Ltd and Lake Harvest Ltd revealed a definite undersupply of smaller fish to these traders and that over 80% of these traders are made up of women. These fish are taken for trade in "informal" markets in lower-income areas in Lusaka


Farmed fish depot, Lake Harvest Ltd, Kitwe.

where they can compete with tilapia from capture fisheries because of their size and price. This indicates that there is a significant market in lower-income areas in Lusaka, though the same companies expressed that this is a small percentage of their total sales as the fish is almost treated as a byproduct.

## Employment

There were about 8000 jobs created through aquaculture in Zambia in 2014 (DoF 2015), with the bulk being created by the large-scale commercial sector, including in the feed and seed sectors as well as in processing (e.g. Capital Fisheries Ltd). A more recent World Bank report (Krishnan and Peterburs 2017) pins this number as high as 13,000 jobs, which are primarily on-farm jobs (including mostly jobs on small-scale farmers, i.e. digging ponds) and mostly unskilled. The report claims that as many as 22,000 jobs may be available in the sector by 2022. Currently, Yalelo has about 500 employees, which means that they have about one person hired for every 4 t produced. The 12,000 registered farmers in the country will hire laborers to dig ponds and net fish. Although these jobs are "informal" and considered piecework in nature, they play an important role in the development of the small-scale sector. According to a WorldFish (2014) report for the ILO, for every 10,000 t of feed produced there could be 100 jobs. This means that by the end of 2017 there could be between 800 and 1000 jobs in the feed sector alone. The same report estimates that for every 1000 t of fish produced, about 100 jobs are created in the value chain (trading, logistics, gastronomy, etc.).

Other benefits not directly accrued within aquaculture in the value chain are those in the agricultural sector that will supply feeds. According to the same WorldFish (2014) report, considering a food conversion ratio (FCR) of 1.7, every metric ton of fish produced will require 1.5 metric tons of soya and maize. Every 10,000 t of fish will therefore require 5,000 t of soya and 1500 t of maize. While this is a market that can be enjoyed by hundreds of farmers, it has to be balanced with the food and nutrition security of rural populations who still depend on maize, specifically as their primary staple food. Other benefactors, such as the female retailers discussed above, are the street vendors, restaurants and traders who can integrate into the value chain. The WorldFish (2014) report states that if the average vendor sells 20 kg of fish a week, and if 5000 t were sold in this way every week, this would create 2500 jobs for traders that can distribute this fish every week.

It is unclear about the role of women and youth in the sector, particularly in small-scale production, which is a topic that requires immediate research if the gains made in the growth of aquaculture are to be equitably beneficial for certain groups. Based on a sample of small-scale registers supplied by district DoF officers, women's involvement in farmed fish production is less than men's and in some districts women's participation is overwhelmingly low.[4]

## Fish supply, consumption and food security

There is limited data available on the consumption of farmed fish in Zambia. While there is some literature on fish consumption in general, with the acknowledgment that farmed fish plays a role in filling the gap between national fish supply and demand (Hichaambwa 2012; Longley et al. 2014; NFDS 2016), disaggregated data on the consumption of farmed fish are not available, and therefore we infer the patterns of consumption based on data from consumption studies on capture fisheries (including mostly tilapia species).

According to the national Demographic and Health Survey (DHS) conducted by the Central Statistics Office (CSO) and the Ministry of Health (MoH) and ICF International (2014), child malnutrition (stunting) rates are still very high in Zambia, although they have declined slightly over the past 5–10 years from 45.4% in 2007 to 40.1% in 2013. Fish provides 55% of the animal protein consumed by Zambians and is an extremely important source of micronutrients and often the only accessible and/or affordable animal-source food for resource poor people in rural areas (Longley et al. 2014; NFDS 2016). In addition, tilapia is a highly favored food for most Zambians though not always affordable for all (NFDS 2016; Genschick et al. In press).

The consumption of fish varies greatly according to geographic location and wealth status. Fish consumption is generally higher in rural areas and low-income groups spend proportionally more on fish than on any other animal-food source, in comparison to high-income groups, though this differs when disaggregated by fish species (Hichaambwa 2012; Longley et al. 2014). In absolute terms, fish consumption per capita is also higher in rural areas than in urban areas, in particular in Northern, Western and Luapula provinces where there are established capture fisheries (NFDS 2016). Some rural areas have high fish consumption per capita—13.9 kg/year reported in Chililabombwe and 27.2 kg/year in Siavonga. The bulk of this fish is made up of dried small pelagic fish or small indigenous wetland species rather than large tilapia (NFDS 2016). This might have an implication on the

productivity of small-scale fish farmers and motivation to practise aquaculture as the supply of fish is largely met by capture fisheries in these areas. While in general, the demand for farmed fish in the country might be high, small-scale fish farmers struggle to reach these markets because of poor infrastructure, long distances to markets and the absence of cold chains.

The price of fresh fish has become the lowest among all animal-source foods in Zambia (Hichaambwa 2012). Because of an absence of cold chains, fresh fish might not be readily available in rural areas and small towns, and sun-dried and smoked tilapia are still highly favored, especially among resource poor people who do not have the means to freeze fish (Hichaambwa 2012). Aquaculture producers sell fish fresh and/or frozen and rarely smoked and/or dried or salted. Despite the high demand and consumption of fish among poor populations, most farmed fish in fresh and/or frozen form is targeted to formal retail outlets and middle-income consumers in urban or peri-urban areas.

Overall, the fish supply per capita in Zambia is on the rise. Figure 4 shows the positive effect that aquaculture has had on fish supply per capita in the country, especially since 2011. The figure shows a rapidly growing population, erratic supply from capture fisheries, increased aquaculture production and imports, resulting in an overall increase in fish supply per capita.

The cultivation and sales of fish of an additional 13,690 t by commercial enterprises in Zambia and increasing imports have helped maintain fish supply per capita, regardless of the growing population, and has resulted in an increase in supply per capita, reaching 11 kg in 2014. This is still significantly below the global average of 19.2 kg/year, but above the sub-Saharan African average of 8.9 kg/year (FAO 2016).

While the increased supply of farmed fish since 2011 has played an important role in the net fish supply, a more significant contribution seems to come from the rapid increase in fish imports over the same period (Figure 4). This drastic growth from 2011 does not seem to be slowing down and the fish sector as a whole in Zambia is being reshaped as consumers are introduced to different fish products such as horse mackerel (*Trachurus spp.*) from Namibia, which was barely on the market a decade ago. Figure 4 shows the importance of fish imports to national fish supply with the net weight of fish and total production exponentially increasing in the last six years to a total of over 55,000 t (more than half of what came from capture fisheries in 2014). Figure 5 shows the change in the fish value chain and imports over time, with dried fish once dominating the import market and today being replaced by frozen fish, namely horse mackerel and tilapia products. In 2014, the market imported just over half the total amount of tilapia produced domestically thus providing an alternative source of farmed tilapia. It is reported in Kaminski et al. (In press) that the imported tilapia is more often of a smaller size and sold at a lower price than domestically produced tilapia, thus potentially providing a marketing barrier for smaller companies to compete in the market.

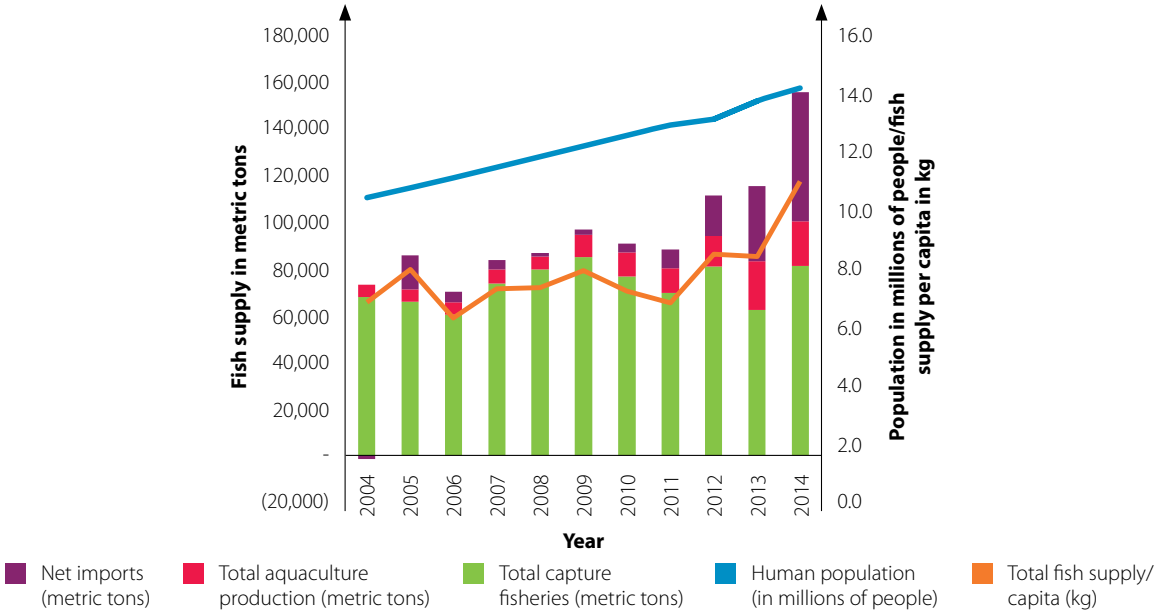



Figure 4. Fish supply per capita in Zambia (2004–2014). Source: Kaminski et al. (In press).

Without fish imports however, the fish supply per capita rate would drop by 3.9 kg (Kaminski et al. In press). This means that imports are providing a crucial function in food security and if the price is lower than domestically produced fish, it is likely that poorer populations are benefitting from this increased availability and cheaper price of tilapia products.

The results of a consumption study in urban Lusaka (Genshick et al. In press) shows that poorer groups there rely on small, dried fish products found only in capture fisheries while wealthier groups tend to consume larger, fresh fish products, such as tilapia, which are partly supplied by aquaculture producers in the country and imported from abroad. The results imply that poorer groups are less likely to supplement their fish demand with fish products from domestically produced aquaculture, possibly because commercial producers generally target the upper-end markets where prices are still high. It also shows that tilapia products may be generally produced for more middle-income populations.

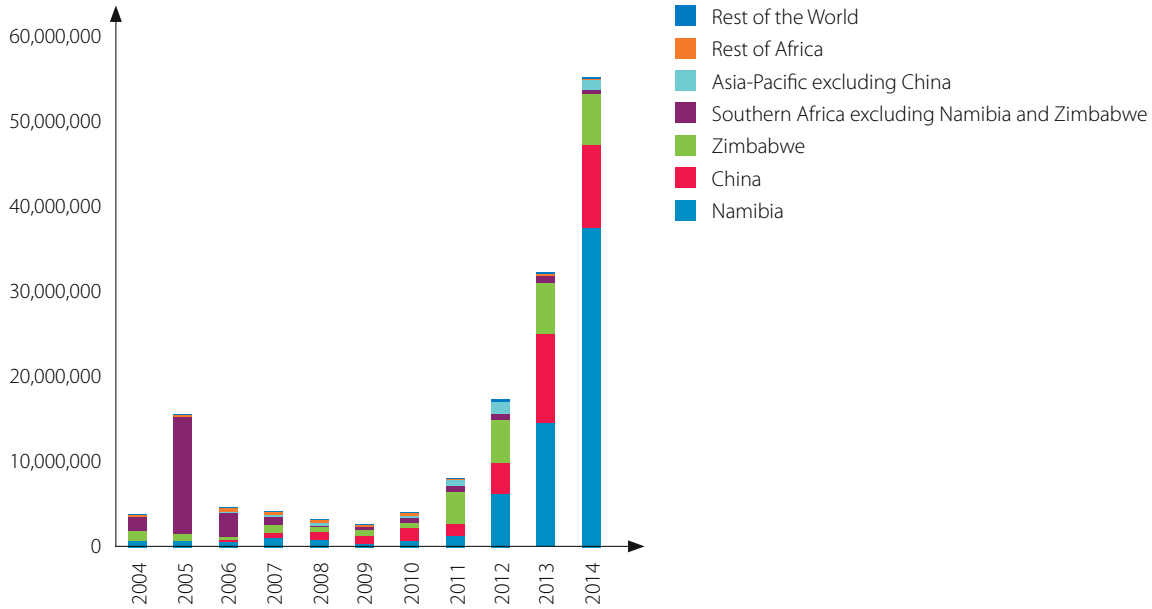



Figure 5. Net weight (kg) of imported fish into Zambia by country or region (2004–2014). Source: DoF and Zambian Revenue Authority (Authors own compilation using Zambian Revenue Authority [ZRA] statistics provided by the DoF)

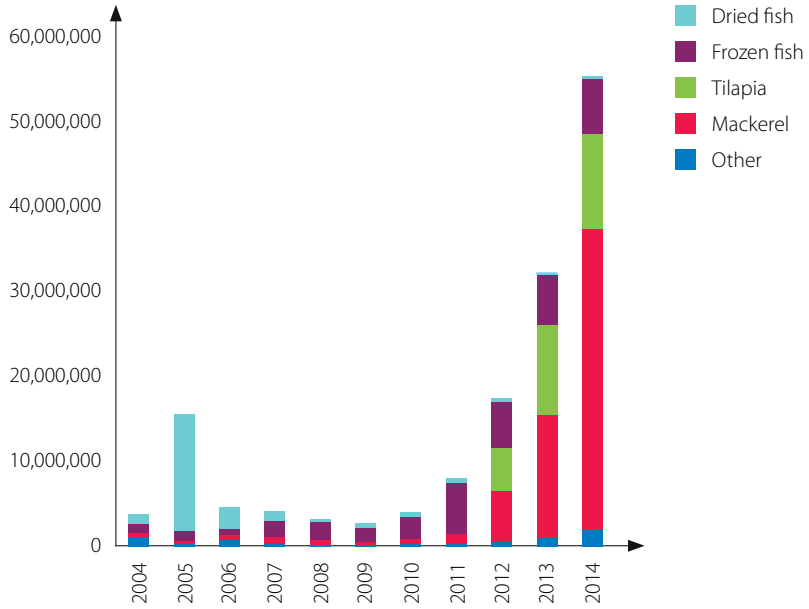



Figure 6. Fish imports by species (Authors own compilation from ZRA statistics provided by the DoF).

# Evaluation of aquaculture's responsiveness toward the needs of the poor

This paper has explored the structure of the aquaculture subsector in Zambia, providing a descriptive account of various components, segments and nodes in the value chain. In this section we attempt to discuss the evident growth and trajectory of the sector and its current responsiveness to the needs of the poor, providing both direct and indirect benefits. The needs of the poor were identified as a need for income, access to a means of production, access to acceptable, nutritious, safe and diverse fish, empowerment (in particular for women and youth), knowledge and access to clean water and sanitation. Given the fact that aquaculture in Zambia is still in its infancy and that there is a shortage of data, the evaluation focuses mostly on how aquaculture provides or does not provide direct benefits to resource poor people by creating income opportunities, increasing their access to inputs and increasing their access to fish. To date, little or no data has been collected or made available on the environmental performance of aquaculture technologies, fish food labeling, empowerment of women and youth (see Harrison 1996 for an exception), or food safety in aquaculture in Zambia. There is a strong need to further research the contemporary role of women in the aquaculture value chain and identify challenges and opportunities for further integration and equitable participation of women in the value chain.

## Income opportunities

Aquaculture contributes directly and indirectly to income generating opportunities in Zambia. There are about 12,000 registered small-scale farmers in the country, of which the majority can be considered relatively resource poor. As small-scale aquaculture enables rural farmers to generate income through the retail of fish as well as for home consumption, a relatively small proportion of the total population benefits directly. With an average household size of eight persons per household, less than 1% (0.64%) of all households in Zambia are engaged in aquaculture. Given the low productivity in small-scale aquaculture, commonly managed by household members and only occasionally requiring seasonal, informal labor, on-farm job opportunities are still very limited in the small-scale sector.

In the commercial sector, according to government statistics, there were about 8000 jobs in aquaculture in Zambia in 2014 (DoF 2015), though this is expected to increase to around 13,000 in 2017 (Krishnan and Peterburs 2017). This also includes employment in the feed and seed sectors as well as in processing. The large-scale aquaculture producers, with vertically integrated production systems, as well as other actors in the supply chain are currently expanding and increasing the number of jobs in the commercial aquaculture value chain. In addition to formal employment opportunities, new niche markets are emerging that are occupied, for example, by street vendors, who access smaller amounts of fish from commercial aquaculture that is traded "informally" in urban areas. Although no data are available, it is believed that "informal" job opportunities are likely to have a greater effect on poverty reduction, especially within downstream value chain activities, and potentially more than from direct jobs in aquaculture production (one large-scale operator can hire around 1 person per 4 t of output, for example). Further jobs within the feed and seed sector have also not been quantified but the introduction of two major foreign feed companies means that formal jobs and also secondary benefits to farmers who need to provide ingredients for local feed production can be realized. Generally, the creation of jobs through aquaculture is directly or indirectly benefitting economic development and likely to make a positive contribution to poverty reduction.

## Access to the means of production

The aquaculture value chain in Zambia has experienced a major transformation as a result of upgrades in pre- and post-production (Kaminski et al. In press). Many of those upgrades have been initiated by large-scale commercial producers, who have vertically integrated advanced feed production and hatchery technologies into their operations or from direct partnerships between companies and different actors in nodes in the value chain (Kaminski et al. In press). Feed mills and private hatcheries have invested in upgrading technologies too. Higher-quality inputs for aquaculture production, namely feed and seeds, have become more widely available, but are mostly utilized by large-scale commercial producers. Thus, although production inputs are being made more available, access to these inputs by small-scale fish farms remains low and cost-prohibitive. To date, access to the means of production in small-scale aquaculture is largely made up of horizontal linkages, such as in the form of farmer networks for fingerling supply and a strong reliance on on-farm resources for feeds and organic fertilizer. By improving access to enhanced production technologies

and knowledge, small-scale aquaculture productivity could increase and more on-farm jobs would be created, which would mean a stronger uptake and integration of aquaculture into rural livelihoods. Fundamental to achieving these development outcomes is making microfinance (with low interest rates) accessible to small-scale farmers to purchase inputs and sustain production. These should be made especially available to women and youth. Currently no microfinance options exist other than through the government-supported Citizens Economic Empowerment Commission (CEEC)[5] or those trialed by development organizations such as SIDA and the FAO-ILO. The demand and preference for fish and in particular the availability of land and water in many rural areas are not considered to be constraining factors to small-scale aquaculture development in the country unlike the accessibility to inputs (including microfinance) and markets, which present the biggest challenges. As cage aquaculture is usually more capital intensive than land-based pond aquaculture, the latter holds the biggest potential for resource poor farmers to venture into aquaculture production.

## Access to farmed fish

The recent aquaculture growth in Zambia has contributed to an increase in fish supply (tilapia) in the country. To date, approximately 20% of the fish sourced in Zambia comes from domestically produced aquaculture. The large-scale commercial sector is the main supplier of farmed fish in the country and accounts for 71% of the approximately 20,000 t of fish produced in 2014 (DoF 2015). The remainder of farmed fish is produced by small-scale fish farmers, though there is high uncertainty on how accurate the statistics are on the total production in small-scale aquaculture. There is an immediate need to quantify not only total production by small-scale farmers, but also to determine the existing number of active fish farmers (disaggregated by sex and age) throughout the country to accurately paint a picture of the small-scale aquaculture sector and assess its inclusion in/or exclusion from a rapidly developing value chain. This would also enable a more thorough assessment of the impact small-scale aquaculture has on food and nutrition security in rural areas.


Employees on commercial farm sorting fish, Great Lake Products Ltd, Mpulungu.

Fish from small-scale aquaculture is consumed, to a certain extent, within the producing household, of which the majority can be considered resource poor. Despite the fact that productivity is low, the 12,000 households in small-scale aquaculture create their own access to fish. The amount of fish that is produced is difficult to decipher and it is common that farmers engage in partial harvesting throughout a cycle in order to supplement their food and nutrition needs or pay for basic expenses (e.g. school fees). The production share that can be retailed locally is usually more expensive than fish from capture fisheries and hence not very competitive in rural markets. It is therefore usually sold to a limited number of slightly higher-income buyers from small district towns and peri-urban areas (e.g. civil servants, teachers, etc.). While these types of transactions only occur for those farmers who are able to produce a surplus, these fish are not generally bought by resource poor people in rural areas who largely meet their fish demands with smaller dried fish products from capture fisheries (both from within and outside[7] Zambia).

In contrast to the accessibility of farmed fish from the small-scale sector, some larger companies from the commercial sector have positioned their production and retail infrastructure in areas with favorable production and marketing conditions (e.g. Lusaka and Copperbelt provinces), where they market their produce directly through their own and other retail outlets. The marketing and placement of these retail outlets do not seem to directly meet the needs of poorer urban populations as fish are mostly targeted to and consumed by middle-income populations. Population growth and a growing urban middle-class are expected to further increase the demand for fish, which can be met by the rapidly expanding aquaculture sector. The questions that remain are whether the small-scale sector has the means to be able to compete and supply fish for this market and whether resource poor urban consumers will be able to afford farmed fish?

It is unlikely that commercial aquaculture will supply consumer preferences and the needs of population groups with limited purchasing power as long as the middle-class demand is still not satisfied. This would require producing small-sized fish, which for now is being filled mostly by imported tilapia. Poorer urban population groups are only benefitting through the "informal" retail of smaller-sized, low grade fish from commercial aquaculture, which is regarded as a "by-catch" and only available in small-quantities in urban areas. This does, however, present an opportunity for small-scale aquaculture to consistently supply smaller-sized tilapia to these lower-income peri-urban and urban markets. Small-scale farmers struggle to grow their fish to larger than 300 g, while the commercial sector markets fish between 300 and 600 g or more. There is certainly a market for fish between 100 and 300 g, which is currently filled by imported tilapia. There is an argument, therefore, that small-scale farmers could produce for this market using minimal inputs if they were to be further integrated into the value chain (e.g. cold chain and transport). The argument is not to supply immature fish but rather to either sell fish that are fed on low-cost feeds and grow to an average size of say 200 g over say a 6-month cycle, or find new species of indigenous fish that have fast growth rates and reach a smaller adult size than what producers are currently supplying to the market today. More research is required to explore such avenues.

The price difference between local and imported fish, as well as the high demand for fish, has allowed both aquaculture supply and fish imports to grow simultaneously in the country with little or no appearance of an adverse effect on each other yet, while also contributing to a rising supply of fish per capita. It remains to be seen what effect increasing fish imports will have on the development of the aquaculture sector. Personnel communication with several large-scale producers reveals that this is still a major cause of concern for commercial farmers. From a consumer perspective, imports may be keeping the price of fish produced and sourced in Zambia relatively low, and thus more accessible for low to middle-income consumers. Little is known, however, on Zambians' preferences for imported fish compared to locally produced fish. Resource poor consumers in urban areas, where most of the imported and commercial farmed fish is retailed, may still have limited access to farmed or imported fish and the main source of fish (e.g. dried, smaller pelagic and wetland species) would still likely be cheaper. This may change if production from capture fisheries continues to decline. The low accessibility of farmed fish by poor consumers is likely caused by the price of fish and not by its acceptability or taste though this requires further research and validation. Tilapia, the dominant species in Zambian aquaculture, is highly preferred across income groups in urban Lusaka (Genschick et al. In press) though it is not always accessible and/or affordable. The outlook for the growth of tilapia farming looks promising, though there is also scope to debate the possibility of further introductions of other species into the sector to diversify the products on the market.

## Final outlook on the aquaculture value chain

The future of the sector will depend on the availability and price of locally produced feeds. The results from this report suggest that commercial feeds are being developed rapidly in Zambia, and new products (inputs) that were not available five years ago are readily available today, albeit mostly in urban centers or commercial production zones such as Siavonga. Two of the largest commercial companies are now partnering with international feed companies, which will likely boost jobs and allow for greater access to feeds by small- and medium-scale farmers. The sector is likely to grow significantly in the coming years and has the potential to transform aquaculture in the country. There are still concerns about the cost of fishmeal and a lack of alternative animal-protein sources in a country with a low diversity of agricultural production. A transformation in the feed industry will largely depend on the source of the ingredients, and the government may have to address the synergies between the agriculture sector and the supply of ingredients for fish feed in a country where food security is still a major concern. Additionally, the cost of commercial feeds is still too high for the majority of small-scale farmers in the country, and the development of supply chains and distribution networks also needs to be addressed. One option to improve the distribution network is through public-private partnerships in which private companies become involved in improving the supply chain (e.g. outgrower schemes) as well as through microfinance institutions that can provide the means for small-scale farmers to invest in their systems.

The aquaculture sector will have to look into the aspect of attaining high-quality seed strains and these need to be made available to more small- to medium-scale farmers. As in many other African countries, this is compounded by the concerns around local fish biodiversity and the effects of introducing improved strains of non-native fish. In Zambia, this has resulted in the ban on *O. niloticus* outside the southern part of the country where the species was already introduced prior to the recent surge in aquaculture growth. This gives the commercial sector around Southern and Lusaka provinces a competitive advantage over other areas where there is mainly small-scale production, such as in Northern and North-Western provinces. This also means it is unlikely that commercial players will spread beyond their current geographical boundaries. This, in turn, means the small-scale sector outside these areas is unlikely to benefit from any spillover effects that commercialization of improved feeds and seeds and better-established supply market chains may bring. The situation surrounding the use of *O. niloticus* is unique to Zambia, but the development of a program for improved indigenous strains could potentially counter this issue, and there is potential for improving indigenous tilapia strains such as *O. macrochir*, *O. tanganicae* and *O. andersonii* to make local strains more available for small-scale farmers. The new loan provided by the African Development Bank aims to develop a genetic improvement program for *O. andersonii* in partnership with WorldFish, and it remains to be seen what dissemination strategies are used for the sector to adopt this strain.

Analyses from Egypt, Ghana, Nigeria, Kenya and Uganda show that the sector grows where conditions support the emergence of small- and medium-scale aquaculture enterprises with a more commercial market-led orientation (Asiedu et al. 2015; Beveridge et al. 2010; Brummett et al. 2008; Hecht 2006). Market demand, resulting from urbanization and a growing middle class, will likely keep driving the expansion of aquaculture on the continent on a more commercial level (Beveridge et al. 2013; Hall et al. 2011). The small-scale sector requires value chain integration strategies and investment plans that remove the sector's dependency on donor-led development projects. Although the integration of the small-scale sector is important, the development of the commercial sector also needs to be nurtured, as it still faces challenges related to practical skills and experience, limited supply of fingerlings and sometimes low quality fry, and low quality and expensive fish feed, as well as infrastructure challenges such as transport. Even though these are all issues that require more research in the sub-Saharan African context, the case of Zambia has shown that, on the one hand, capital influx and market-led approaches can significantly develop the aquaculture sector and have spillover effects on the inputs industry (such as feed and seed), while also producing more fish for markets. The commercial sector also seems to hold potential for spillover effects into the small-scale sector, especially on input supply, though evidence for this is limited to a few areas adjacent to commercial operators. On the other hand, there is a possibility that these developments will further marginalize small-scale farmers, since they might be unable to compete with the commercialization of the industry and to supply a market dominated by middle-class consumers. Small-scale farmers may need to develop a different niche among lower-income consumers. Food security is still a major concern in Zambia and the increase in production of fish could be an important contributor to mitigate malnutrition. More effort needs to be

made to make farmed fish more accessible to poorer populations, whether by introducing new species into the sector that are cheaper to cultivate, decreasing the costs of production to produce cheaper fish, or for some farmers to generally produce smaller-sized fish that require lower-cost inputs.

Photo credit: Alexander Kaminski/WorldFish

Small-scale farmers netting a pond, Kawala, Mbala District.

# Conclusion

It is evident that there have been vast developments and improvements in aquaculture in Zambia in recent years. Aquaculture production is on the rise though mainly driven by the large-scale commercial sector, which is generally detached from the small-scale sector. These sectors are responding to the needs of the poor differently, and have the potential to respond better in the future. The small-scale aquaculture sector can be characterized as low input-low output where the resource poor people access fish from their own production and to generate some income through the local retail of fish. Both the consumption and income linkages, although nominal, are considered important for poverty reduction and household food security. Improved access to inputs such as feed and seed are likely to help increase productivity and hence stimulate incentives for more small-scale farmers to venture into aquaculture. To allow small-scale farmers to produce more fish and to follow more business-oriented farming, market access needs to be improved. Fish from aquaculture is expensive compared to most small fish from capture fisheries and thus current markets in rural areas are limited and competitive for farmed fish. Most resource poor people who are not directly involved in small-scale aquaculture are not able to directly or indirectly benefit from fish farming, neither through improved access to fish nor through on-farm job opportunities. Such indirect benefits, however, emerge partly from the developments in the large-scale commercial aquaculture value chain. The growth of the commercial value chain demands more labor and creates formal and "informal" income opportunities in on-farm production as well as in pre-and post-production. The fish produced by the large-scale commercial aquaculture sector, however, is mainly feeding the urban middle-class in selected provinces. Hence, poorer consumers in many parts of Zambia do not benefit from an increased fish supply through large-scale commercial aquaculture. While it is assumed that the large-scale commercial sector will keep growing, it will be important for producers and input suppliers to increase their market share and devise products that are more accessible for lower-income populations, i.e. by lowering the cost of production. The aquaculture value chain in Zambia is an important exemplar for the development of the sector in the region, and while some challenges still remain, the sector should be carefully studied over the next years in order to track the trajectories and assess the impacts on poverty alleviation.

# Notes

[1] https://www.afdb.org/en/documents/document/zambia-aquaculture-enterprise-development-project-93700/

[2] Farmers in the Philippines are ranging between 4 and 8 t/ha/year with a fast growing niloticus species, while earthen ponds in China produce well over 6 t/ha/year), making it further speculative that small-scale farmers in Zambia could achieve such high productivity rates with the absence of a functioning supply chain in some parts of the country (Jamu 2001).

[3] https://openaid.se/activity/SE-0-SE-6-5119004901-ZMB-31120/

[4] For example, in Kasempa District (Northwestern Province) and Mpulungu District (Northern Province) around 40% of fish farmers are women and only 16% are women in Mbala District (Northern Province).

[5] http://www.pgzambia.com/ceec-gives-k12m-fish-farmers/

[6] For example, *Rastrineobola argentea*, (known as *dagaa* in Tanzania), a small pelagic cyprinid, found in the Lake Victoria area, East Africa.

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This publication should be cited as: 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.



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