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# Commercialization and upgrading in the aquaculture value chain in Zambia

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ABSTRACT

After decades of government and donor-run programs that sustained extensive aquaculture systems, Zambia has experienced market-led capital investments that have facilitated significant growth in production. The emerging commercial sector is characterized by investments in intensive cage and pond-based aquaculture of mostly non-native tilapia species, which today makes up the bulk of annual production. To better understand this transformation we used a Global Value Chain (GVC) analysis to examine evidence of upgrading trajectories and various forms of coordination that govern the chain. A quantitative survey of smallholder farmers in Northern Province (n = 223) was designed to surface insights on the productivity of small-scale farmers and evaluate their position of strength within the chain. The survey reveals the extensive nature of rural, small-scale fish farming and suggests that farmers produce mostly for subsistence purposes and in isolation from the commercializing value chain. We also provide data from 22 key informant interviews with lead firms and stakeholders in the aquaculture sector to provide insights on upgrading and the forms of coordination between nodes and firms. Our findings show that upgrading in value chains is taking place in all its forms, i.e. through investments in high value products, improvements in operations that produce more efficiently, adopting upstream or downstream chain functions, and utilizing competencies from different chains into aquaculture-related operations. Much of this is possible because of increasing vertical integration of operations and tighter contractual relationships between firms and nodes. The value chain and markets in Zambia are thus dichotomized, where on one side there is an extensive smallholder sector, supported by government-run services, and little access to inputs and markets; and on the other side, a burgeoning commercial sector with a few pioneering lead firms who have shaped the commercial value chain and who dominate total production. Finally, we combined various government statistics to reveal the growing fish supply per capita rate between 2004 and 2014. We also provide data on fish imports to locate the Zambian aquaculture value chain in the larger global picture and present some insights into what many key informants in the industry feel is an increasing obstacle facing the sector. Analyzing upgrading and coordination trends is critical in understanding the emerging aquaculture value chains in sub-Saharan Africa.

## 1. Introduction

Aquaculture is the fastest growing food production system in the world (FAO, 2016), however, Africa has not kept up with the pace of growth achieved elsewhere (Beveridge et al., 2010; Brummett and Williams, 2000; Brummett et al., 2008; Hecht, 2006; Hishamunda, 2007; Moehl et al., 2006). At present, the whole of Africa contributes 2.3% to total global production volumes, of which two-thirds is produced in Egypt (FAO, 2016). Aquaculture in sub-Saharan Africa thus contributes less than 1% of the total global production. Projections for sub-Saharan Africa predict a decline in fish consumption per capita at an annual rate of 1% until 2030, resulting in an average of 5.6 kilograms (kg) of fish per capita per year (Kobayashi et al., 2015). Such projections do not take into account the role of aquaculture as part of the solution to overcome fish-supply deficits in many African countries, where the agro-ecological conditions are well suited for aquaculture development (Aguilar-Manjarrez and Nath, 1998; Kaspetsky, 1994).

Historically, government and donor-driven programs have set the pace and alignment of aquaculture development in Africa, mostly through targeting smallholder production to increase food and nutrition security at the household level (Brummett et al., 2008; Hishamunda, 2007; Jamu et al., 2012; Moehl et al., 2005). This has resulted in the establishment of extensive, small-scale farming systems under limited

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capital and low quality input regimes, which produce mostly for home consumption or to pay for immediate expenses (Brummett et al., 2008; Dey et al., 2006). Given the extensive nature of aquaculture systems in Africa, limited investments have been made by actors in the value chain, domestically or internationally, specifically into the quality of inputs and services required for upgrading (Beveridge et al., 2013; Brummett et al., 2008; Hecht, 2006).

Recently, some countries in Africa, including Zambia, Nigeria, Uganda, Kenya, and Ghana have experienced significant growth in aquaculture albeit from a low baseline, and there are examples of increasing intensification and commercialization in the value chain (Asiedu et al., 2015; Kassam and Dorward, 2017; Miller and Atanda, 2011). A favorable economic climate, the growing strength of domestic markets due to a rising demand for fish from a rapidly emergent middle class (Tschirley et al., 2015), and the increasing price of wild-caught fish are cited as factors that have enabled aquaculture development in Africa (FAO, 2016; Hecht, 2006). Commercial growth in the value chain occurs, in most cases, from market-led investments in large-scale, capital-intensive technologies, such as cage-culture in Ghana (Asiedu et al., 2015; Kassam and Dorward, 2017), and land-based rearing units in Nigeria (Miller and Atanda, 2011) but also from investments into research, such as in genetic improvements programs in Egypt (Rezk et al., 2009). Such upgrades in the value chain have tended to significantly impact the sector though they are rarely documented in Africa.

In this paper we aim to contribute to the literature on emerging and transforming aquaculture value chains in Africa by examining recent developments in the aquaculture sector in Zambia. The overall objective was to map the current value chain, describe the actors and stakeholders and understand the dynamics that have led to transformation in the value chain. We use a Global Value Chain (GVC) analysis and focus in particular on evidence of upgrading trajectories that have enabled commercial growth. The analysis further focuses on forms of coordination between lead firms (and external actors) that govern these trends and interactions. It is hoped the analysis provides greater insights into some of the emerging value chain trends in aquaculture in Africa.

## 2. Upgrading and coordination in Global Value Chain analysis

Value chains are usually defined as the full range of processes that are required to bring a product from its conception to its end use (Kaplinsky and Morris, 2001). GVC analysis is a tool that has been increasingly applied to commodity value chains, in particular to analyze international trade and ways in which actors in developing countries can upgrade and strengthen their position in the chain, in this case in the global aquaculture sector (e.g. Barrett, 2002; Bush and Duijf, 2011; Jespersen et al., 2014; Ponte et al., 2014). GVC focuses on analyzing actors, structures and dynamics of value chains, focusing particularly on the typologies of various actors and the activities, linkages and relations between them (Bolwig et al., 2010). To date, such studies have centered on areas with more developed aquaculture value chains and a long history of aquaculture production. GVC analyses are lacking in areas that are not considered major aquaculture producers (Lim, 2016).

GVC literature focuses around two critical issues, namely how and what type of upgrading takes place and what forms of coordination govern such developments. Upgrading is used as a concept to identify ways in which an actor can strengthen their position in a value chain by improving their horizontal and vertical relations, improving their activities and functions and bettering their overall performance and position of strength in the chain. Four categories of upgrading are commonly recognized: product, process, functional and inter-chain upgrading (Humphrey and Schmitz, 2002). These relate to producing more valuable products, producing more efficiently, acquiring new functions with higher skill levels, and applying competences from one chain and using them in another (Ponte et al., 2014).

Coordination in a value chain is defined as the efforts or measures that players make in a market system to act in a complementary way towards a common goal (Poulton et al., 2004). This especially focuses on the types of relationships between actors (e.g. between buyers and suppliers). Distinguishing between these relationships requires an analysis of value chain governance, i.e. by analyzing the exchanges, flow of materials, resources, and information within the chain. Such exchanges and relationships are often governed by 'lead firms', which organize at particular positions in the chain and are able to shape (coordinate) the chain, e.g. in terms of standard setting, pricing, and role specification, among other things (Bolwig et al., 2010).

This paper focuses specifically on two forms of coordination by which lead firms exercise their position and power in a value chain, namely, (i) *hierarchy* (vertical integration where an actor performs several functions), and (ii) *contractualization* (various horizontal and vertical contracts between nodes and specific actors – see Kelling et al., 2013). For a more common classification of coordination used in more established value chains, see Gereffi et al. (2005).[1] The two forms used in this analysis are more appropriate to infant industries where there are few actors and a relatively short value chain.

Lead firms that perform upgrading and coordination activities in a value chain form part of a larger institutional framework, which includes government departments or 'external actors' such as development organizations. The institutional framework and enabling environment forms the backdrop in which firms perform upgrading and coordination activities and is thus a critical component of value chain governance. We therefore distinguish between overall forms of governance (analyzing the institutional framework) and forms of coordination (analyzing lead firms and relations between various actors within the chain) but only focus on the latter in this paper. An analysis of the former would require an institutional and/or stakeholder analysis, which this study was not able to conduct. We recognize the urgent need for such an analysis, especially in Zambia where aquaculture is emerging. It will be critical in the future to assess the institutional arrangements and enabling factors that lead to certain upgrading trajectories in aquaculture on the sub-Saharan African continent.

## 3. Materials and methods

The key processes in the Zambian aquaculture value chain, including the production of fish, value addition, trading, and marketing of the final product to consumers, as well as the inputs, services, and institutional enablers that are required for these processes (De Silva, 2011), were assessed where possible. Using primary and secondary data we analyzed the value chain in reference to instances of upgrading and forms of coordination recognized in the GVC literature.

### 3.1. Secondary data

Data from several government sources was collected in an attempt to better understand how the increasing production from aquaculture contributes to annual fish supply per capita. The government sources used in the analysis were as follows: (1) capture fisheries and aquaculture production data from the Department of Fisheries (DoF) of Zambia (1995–2014)[2]; (2) population data from the Central Statistics Office (CSO) of Zambia (2004–2014); (3) trade data from the Zambian Revenue Authority (ZRA) on imports and exports of fish (including farmed fish) from (2004–2014).[3] We combined this data to calculate the fish supply per capita rate and the market share of aquaculture compared to capture

[1] According to the classification of value chain governance in Gereffi et al. (2005), *contractualization* would fall somewhere between *market* and *hierarchy*. However, in areas where lead firms operate in an infant industry, *relational* value chains may also be evident.

[2] This data is published in various government reports and the authors (including a high ranking aquaculture research officer) compiled the data over several months.

[3] This dataset is not published in any form and has been compiled over years by the ZRA. This paper is the first to publish data on fish imports in Zambia.

fisheries. We also collected data from a state-run hatchery in Kasama, Northern Province on fingerling production and sales (2005–2015)[4] to understand the total production and overall function of government hatcheries. The data from the hatchery is also used to verify findings from a survey that we implemented with fish farmers in the same province. There is limited information on aquaculture in Zambia in peer-reviewed literature especially the availability of robust data that would allow to verifying data from government statistics, which are largely based on estimates rather than rigorous data collection methods.

### 3.2. Primary data

Primary data were collected through quantitative and qualitative methods. A quantitative fish farming survey was conducted among 223 households in Mbala and Luwingu districts in Northern Province, Zambia. The survey presents descriptive statistics on the types and sources of inputs (feed and seed), pond productivity, and marketing of the final product to provide insights on the level of productivity of farmers and their position of strength in the value chain. The data was collected between January and February 2016, and covers 35% of the 637 farmers registered in the two districts. These sites were chosen because WorldFish was already working with farmers in these districts under an Irish Aid funded program. The baseline information was used for WorldFish project implementation purposes. Enumerators from WorldFish worked together with DoF officers using purposive sampling to locate and interview farmers, selecting participants that were available on the day the survey was administered. The survey found that 16% of the sample had abandoned production (or currently not farming) and thus the averages presented in the Results section below are based on a total sample of 188 active farmers.

Northern Province has the second highest number of small-scale fish farmers in the country, with 2436 registered farmers in 2014, around 20% of all small-scale fish farmers in the country (DoF, 2015). The sample in our survey makes up 9% of all fish farmers in the province. Whilst we recognize that the sample is not statistically representative of all small-scale farmers in the country, we maintain that, generally, the sample is indicative of the productivity and the reality of input availability and market access for small-scale farmers in rural Zambia. The survey allows for a deeper understanding of small-scale fish farming in the country and was designed to verify the estimated productivity data on small-scale farmers in government reports.

Secondly, primary data were collected through key informant interviews with key players in the commercial aquaculture sector. The objective of the interviews was to verify existing government statistics on aquaculture production volumes in the commercial sector, and to understand the factors that led to instances of upgrading in the value chain. Key informant interviews were conducted in April 2016 and again in March 2017 with large- and medium-scale producers, input suppliers, key institutions governance institutions and wholesale/retail actors. The interviews were conducted through semi-structured questionnaires with high ranking and influential individuals representing the various stakeholders (between one and two in each interview). Questions focused on the history of the companies/organizations, production economics (e.g. system parameters, stocking densities, feeding regimes, species, production yields, etc.), operations, marketing strategies, and forms of coordination between actors in the chain. In total we conducted 22 interviews: three private hatcheries (out of a total of 6 known hatcheries in the country), six feed companies (out of a total of 8 known feed mills in the country) nine large-scale cage-culture and land-based producers (around half of all operators in the country and over 80% of market share), one commercial association and aquaculture lobby group (the only existing association), the largest fish trading and processing company in Zambia (largest in terms of market share) and two government officials from the DoF headquarters in Chilanga and the provincial office in Kasama, Northern Province.

## 4. Results

### 4.1. Background to aquaculture in Zambia

Aquaculture in Zambia dates back over fifty years, when the government undertook fish farming trials and set up aquaculture research stations in the 1960s. By the 1970s, the Department of Fisheries (DoF), a newly formed body, took an active role in rolling out small-scale aquaculture development programs in rural areas under a banner of food security, and by setting up government-hatcheries and training programs on basic pond management (Mudenda, 2009). International donors have since taken an active role in developing and supporting the rural aquaculture sector over decades, such as the United Nationals Development Programme (UNDP), United States Agency for International Development (USAID), Japan International Cooperation Agency (JICA), Norwegian Agency for Development Cooperation (NORAD), Food and Agriculture Organization (FAO), United States Peace Corps, WorldFish, etc. This has mostly created and sustained the smallholder sector through what Belton and Little (2011) call *interventionist* or *project-based* models.[5]

Commercial aquaculture in Zambia has a relatively shorter history. Not until the late 1990's, did the private sector take notice of the potential for fish farming, learning especially from the success of cage culture developing on Lake Kariba in the neighboring country of Zimbabwe. In the 1990s there were only three cages on Lake Kariba in Siavonga District in Southern Province of Zambia, started at the time by lodges to feed palm-sized tilapia to guests (Mudenda, 2009). At the time, cage culture had started growing rapidly with a total yield of 3500 metric tons (mt) in Zimbabwe compared to 30 mt in Zambia (Halwart et al., 2007). In 2014, over 3800 mt was reported to come from cage culture in Zambia (DoF, 2015). According to key informant interviews that we undertook in 2016 and 2017, this is reported to have grown to over 8000 mt by the end of 2017. Today the commercial sector in Zambia is largely located in the south of the country in Lusaka and Southern Provinces. This is partly owed to the area's proximity to the capital, Lusaka, and because of the permission to use non-native *O. niloticus* in the Kafue Flats and Lake Kariba, where the species was introduced decades earlier. The species is not permitted for use in other parts of the country as per the *Fisheries Act No. 22 of 2011*.

Cage culture farming is situated mostly around Lake Kariba. Intensive, land-based pond farmers are located around the Kafue Flats and the Copperbelt Province. By 1996 as little as 1500 mt was being produced by the whole private sector (including cages and pond farmers) in Zambia compared to an estimated 13,600 mt in 2014. Aquaculture contributed less than 5% of the total fish supply in Zambia in 1995 to more than 20% of the total fish supply in 2014,[6] translating to an annual growth of 11.56%. The Zambian aquaculture sector today is characterized by a value chain with two distinct and separate subsectors (Fig. 1), a traditional sub-sector driven by donor and government support of smallholder farmers, referred to by the DoF as the ‘small-scale’ sector; and an emerging, commercial sub-sector driven by capital investments into medium and large companies, referred to as the ‘large-scale’ sector. The DoF defines this differentiation by classifying large-scale farmers as those that produce more than one ton per year[7] (DoF, 2015). This differentiation can be problematic as it fails to

[4] The authors and DoF officers collected this information from hardcopy reports dating back to 2005 and the compiled dataset has never been presented in this format.

[5] For an account of donor-driven and government-run interventions and their perceived lack of success in Zambia, see Harrison (1996).

[6] Capture fisheries still contribute the bulk of total fish production with 80,826 mt in 2014.

[7] We appreciate that typologies of aquaculture farmers are complex and due to space constraints are unable to address this. For a useful analysis on the topic see Kassam and Dorward (2017).

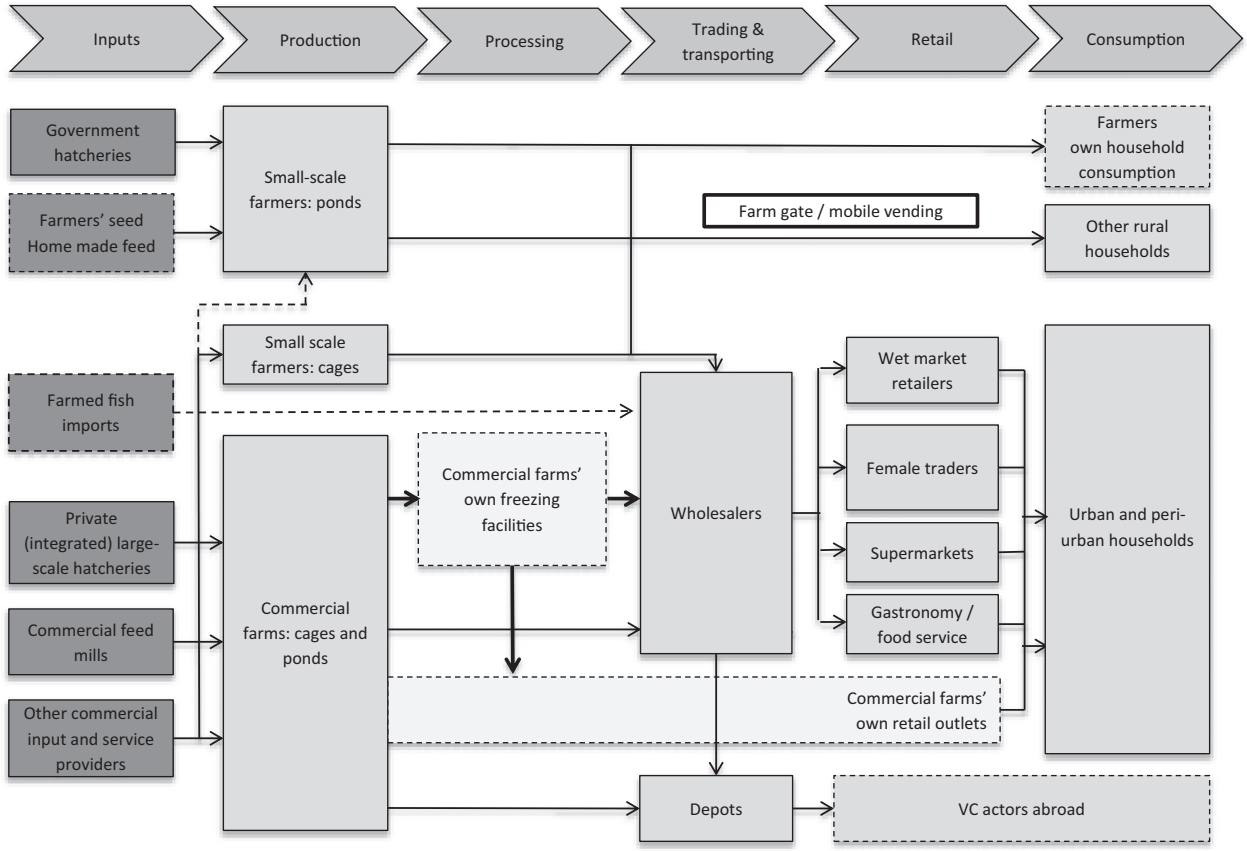


**Fig. 1.** Map of the aquaculture value chain in Zambia.
Source: Author's drawing based on collected data.

capture the range between subsistence and commercial operations, including the socio-economic context. In order to stay within the government's framing, we still use the term 'small-scale' throughout the paper to represent rural, mostly subsistence-based farmers that have little or no access to commercial services, inputs and markets. We refer to 'large-scale' as those commercial producers that perform a leading role in shaping the value chain, bearing in mind that some companies can produce up to 2000 mt a year whilst others might produce less than 50 mt. Both value chain sub-sectors are dominated by the monoculture of tilapia species[8] (99% of the market share[9]).

### 4.2. The small-scale sub-sector

In 2014, according to government statistics, there were 12,010 'small-scale farmers' operating extensive, earthen pond systems at the household or community level, usually in rural or peri-urban areas (DoF, 2015). Most of these farmers (around 88%) are found in provinces with no major urban cities, with the remainder found in Lusaka, Southern and Copperbelt Provinces. These areas are considered as major urban hubs or aquaculture production zones (DoF, 2015). According to the DoF statistics, the small-scale sector produced 2954 mt in 2014[10] (see Fig. 2).

Our fish-farm survey in Northern Province found a productivity rate of 1.06 mt/ha on average (n = 188) for the most recent production season (2015). Other studies confirmed similar production levels of between 0.5 mt/ha and 3.1 mt/ha, depending on location, and input use (Musuka and Musonda, 2013 and Nsonga, 2015 respectively). The government measures the total square meters of ponds in each district and then ascribes a rate of 6.75 mt/ha to all farmers. Key informants from the government argued that, due to a lack of resources, capacity and the vast geographic distribution of farmers, they have to estimate total production. It is difficult therefore, to make meaningful conclusions on the total volumes produced from small-scale farmers in the country. Hence, we use our own small-scale farmer survey to provide insights into the reality and productivity of smallholder farmers.

Data from our small-scale farmers survey confirms that all of the practicing farmers (n = 188) relied on fertilization using compost and/or household or animal waste. A quarter of the surveyed farmers reported the additional use of pelleted feed although 77% of these farmers received this feed from development institutions.[11] Farmers did not use any other ingredients (i.e. maize bran, soy, etc.) as feed.

The same survey showed that 41% of fish farmers used most of their harvest for household consumption, whilst the remainder stated that most of their harvest is sold at farm-gate or used for barter.[12] Value chains originating from small-scale farmers are short, with the majority of fish sold at farm-gate and/or through mobile vending in surrounding villages and markets. This is further confirmed from results in other

[8] Tilapiine cichlids herein called 'tilapia(s)' and locally referred to as 'bream(s)' – namely, *O. niloticus*, *O. andersonii*, *C. rendalli*, *O. macrochir* and *O. tanganicae*.

[9] This is an estimate made by DoF since some commercial farmers have tried to grow *Clarias* spp. and *Cyprinus carpio*, though the production is still insignificant in Zambia.

[10] Note that in Fig. 2 the total is shown to be 5591 mt. The remainder is estimated to come from government programs that re-stock small water bodies and dams, which are regarded as culture-based fisheries. The DoF records this under aquaculture statistics rather than capture fisheries. Little is known or documented on this sub-sector and it has been omitted from the analysis.

[11] WorldFish was working with farmers on developing local feeds in villages located in the two districts. This may skew the view that there is a consistent supply of feed by development organization when in fact there is not.

[12] Actual quantities could not be measured as the survey relied on recall methods and farmers did not weigh fish.

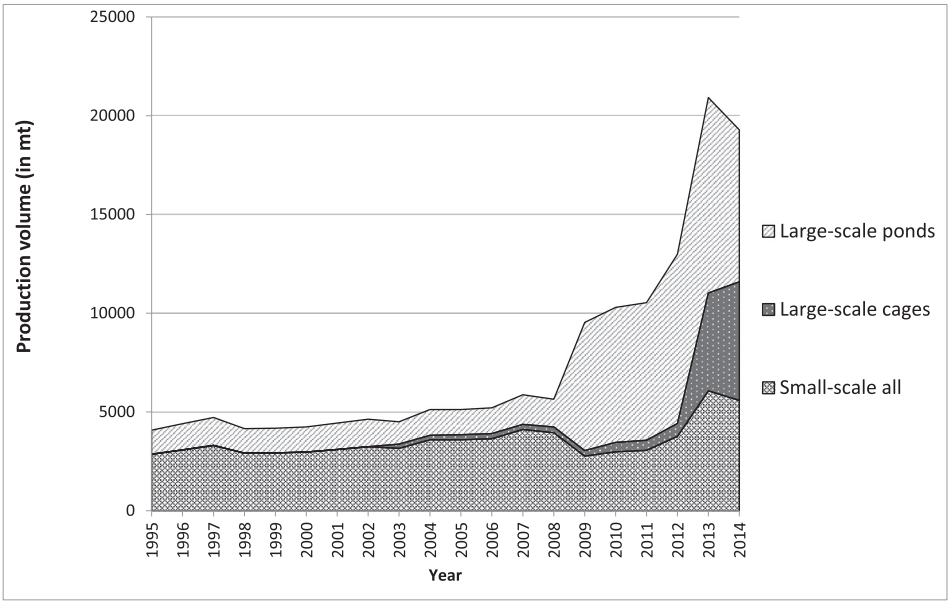


**Fig. 2.** Aquaculture production volumes from small and large-scale systems (1995–2014). Note: 'Small-scale all' includes smallholder pond farmers and government stocking programs of small water bodies and dams (see footnote 10).
Source: DoF production data (1995–2014)

studies (Nsonga, 2015; Musuka and Musonda, 2013).Only 8% of surveyed farmers ranked aquaculture as their primary income sources.[13]

### 4.3. The commercial sub-sector

The production data from the DoF databases for large-scale aquaculture is thought to be more reliable than for the small-scale sector given that there are fewer commercial farms in the country and because of the dependability of on-farm record keeping. There were twenty registered 'large-scale' land-based pond producers and twelve lake-based cage-operators in Zambia in 2014 (DoF, 2015), which registered a total estimated output of 13,600 mt. Around 40% of this production comes from three farms (Yalelo, Lake Harvest Ltd. and Kafue Fisheries Ltd.), regarded by the authors as 'lead firms' in setting the standards for cage and land-based production in the country (i.e. price, size of products, target market, etc.). Other farms recorded in DoF statistics and from our key informant interviews are smaller cage culture operators on Lake Kariba, one on Lake Bangweulu (Kambashi Fisheries) and another on Lake Tanganyika (Mpende Fisheries); and medium-to-large land-based pond farmers in Southern, Lusaka, Copperbelt and Northern Province. Kafue Fisheries Ltd. is by far the biggest of the pond producers with over 100 ha of ponds compared to other operators that have less than 40 ha and most of whom have less than 10 ha.

The production data (see Fig. 2) show two key moments of growth between 1995 and 2014. First, the data show a leap in production volume in 2009 from large-scale land-based ponds and a second in 2013 from cage culture. In 2009, Kafue Fisheries Ltd. upgraded their production units in size and acquired new technologies (changing from the local *O. andersonii* strain to an imported *O. niloticus* strain). The company also improved their feeding regime by complementing their existing fertilization (integrated aquaculture with pigs) with newly developed, domestically produced aquafeeds. In 2015, the company produced over 1500 mt of tilapia (*O. niloticus*) per year (Operations Manager, Kafue Fisheries Ltd. pers. comm.). Kafue Fisheries Ltd. was one of two Zambian farms who were initially part of a government project in the late 1980s and early 1990s that promoted integrated pig/fish and crocodile/fish production (Kalimba Farm), in an effort to cope with a lack of domestically produced feeds at the time. Initially, both companies produced indigenous *O. andersonii* in an effort by government to promote local species. Kalimba Farms is one of the only large-scale producers that still grow *O. andersonii*.

The leap in production volumes in 2013 can mostly be attributed to the entrance of two major cage-culture players on Lake Kariba in Siavonga District, Southern Province. The first, Kariba Harvest Ltd., a subsidiary of the Zimbabwe-based Lake Harvest Ltd. invested on the Zambian side of Lake Kariba partly because of the political and economic crisis in Zimbabwe after the turbulent 2008 elections. Yalelo, a Zambian company invested shortly after, also in 2009, citing the enabling environment and investment climate at the time. Whilst both these firms registered and started initial production in 2009, years of Research and Development (R&D), trial phases and environmental impact assessments restricted the companies until they expanded production in 2012/13 (Operations Manager from both companies pers. comm.). Today these two companies make up 30% of the total commercial output and over 85% of the total volume of all the cages on the Zambian side of Lake Kariba (DoF, 2015).

### 4.4. Seed supply

#### 4.4.1. Government hatcheries

The (small-scale) aquaculture sector is supplied with mixed-sex native tilapia fingerlings from five government hatcheries across the country. The government hatcheries still provide the bulk of the seed supply for small-scale farmers and supplied about 516,000 fingerlings of various native Tilapiine strains, mostly *O. macrochir*, *C. rendalli* and *O. andersonii* in 2015. These numbers do not match the total estimated output that is projected for the small-scale sector for the country in DoF statistics, especially because the majority of these small-scale farmers are located in areas where there are no private hatcheries and where government hatcheries represent the only source of seed. This leads us to conclude that either the government hatcheries are misrepresenting fingerling sales or the total reported production from small-scale farmers is indeed an overestimation. In this case, we turn to our small-scale survey to provide more clarity on the source of seed for small-scale farmers. We also provide secondary data that we collected from a government-run hatchery in Northern Province (Misamfu Aquaculture Research Station) to assess the source of seed for small-scale farmers in the province.

The fingerlings produced by at Misamfu Aquaculture Research Station are not all used in aquaculture. According to production data (2005–2015), approximately 54% of the seed produced was used for re-

[13] For an anthropological account of fish farmers' motivations in Zambia see Harrison (1996).

stocking programs of small water bodies and dams over a ten-year period. The remainder was distributed to small-scale farmers in the province, either through development organizations (59% of which was ordered by these actors directly[14]) or sold to farmers at the hatchery gate. The DoF distributes fingerlings to some small-scale farmers though a lack of capacity and resources restricts the department to do this consistently. The relatively low percentage of seed directly supplied from government hatcheries to small-scale farmers is in agreement with data we collected at farm-level. Of all active small-scale farmers in our survey, 44% sourced fingerlings from fellow farmers,[15] 24% received fingerlings from development organizations,[16] 16% collected their fingerlings from the wild, and 16% of farmers purchased their fingerlings directly from a government hatchery, whilst none bought their seed from private hatcheries. Acquiring fingerings from fellow farmers is the most popular source of seed and further investigation revealed that farmers do not consistently purchase fingerlings every year but instead allow fish to breed for generations thus recycling their stock year after year (Provincial DoF Officers pers. comm.). This creates obvious problems with inbreeding and stunted fish growth. A more thorough analysis of these farmer-to-farmer seed distribution networks is required.

#### 4.4.2. Private hatcheries

Private hatcheries are relatively new nodes in the Zambian aquaculture value chain located in Lusaka, Southern, Northern and Copperbelt Provinces, where most of the large-scale, commercial aquaculture is situated. These provinces (save Northern Province) have areas where non-native *O. niloticus* was previously introduced. They are also in close proximity to urban cities with well-developed infrastructure (i.e. roads, electricity, cold chain, etc.). There are two types of private hatcheries: the first type is a standalone hatchery that only produces and sells seed to farmers of which there are only six in the country, all located in Lusaka, Southern or Copperbelt provinces. The second type is a vertically integrated hatchery of a large-scale aquaculture operator. From our key informant sample, all nine of the producers interviewed had their own integrated hatcheries. Whilst these producers noted that there are some small-scale farmers that buy from their hatchery units, it is not a mainstay of the business, and the total share of seed sold to these farmers is thought to be nominal. One of the standalone hatcheries, Palabana Fisheries, has begun supplying tilapia fingerlings and technical training through an out-grower scheme for peri-urban small-scale farmers located in close proximity to the hatchery to stimulate growth in small-scale aquaculture and to create a sustainable demand for fingerlings. Such trends to coordinate exchanges between small-scale farmers and input suppliers in the value chain are not yet common in Zambia.

It is difficult to date back when improved breeds were first imported to Zambia, but with the introduction of *O. niloticus* at least two private hatcheries have since recruited hatchery managers with Philippine origin and work experience in Thailand to incorporate necessary technical knowledge into their operations (mostly due to a lack of expertise in Zambia but also to gain competitive leverage in the sector). Besides various tilapia species, some private hatcheries have also started to explore breeding program for catfish and carp (for potential export market or to target local expatriate markets).

At present the non-native *O. niloticus* makes up the majority of the total production volume of tilapia. By our estimates, based on key informant interviews, large-scale operators and hatcheries produce around 50 million fingerlings per year. This would come close to matching the government statistics of total commercial output with 50 million minus 10% mortality multiplied by an average of 300 g-sized fish, thus equaling 13,500 mt. Most key informants stated that their hatcheries were producing below capacity. The implication of these estimates is that the contribution of fingerlings from the private sector to small-scale farmers is still mostly insignificant.

### 4.5. Feed supply

By 2017, eight feed mills have established a supply of domestically produced pelleted feed (sinking and floating) for commercial aquaculture. Whilst exact production data is unavailable, we have estimated, based on key informant interviews with feed mills, that domestic production of aquafeeds reached around 30,000 mt in 2016. All feed companies interviewed stated that they were producing below capacity. Commercial fish farms from our interviews had an average Feed Conversion Ratio (FCR) of around 1:1.7 meaning that the above estimate of total feed production would create 17,647 mt of fish. This amount is considerably more than the 13,600 mt projected by commercial farmers in DoF statistics for 2014, however, interviews with key informants took place in 2016 and 2017 meaning that there could have been new entrants (producers) to the sector or producers may have expanded production volumes since the estimates projected for 2014. Yalelo and Kariba Harvest Ltd. for example, have both significantly expanded production since 2014.

Six of these feed mills are Zambian companies that already produce feed for the poultry and livestock sectors and started production of aquafeeds roughly around the same time as commercial aquaculture started to develop on Lake Kariba and the Kafue Flats (namely from Yalelo, Kariba Harvest Ltd. and Kafue Fisheries Ltd.) between 2009 and 2013. These three large farms entered into contractual negotiations with the existing feed mills to research and develop aquafeeds. This created a race between mills to attempt to gain a competitive advantage in the market, supported by producers who wanted to rely less on imported feeds. One feed mill, Novatek Animal Feeds, partnered with Yalelo to research on developing locally produced feeds, based on a soy surplus that was said to exist in the country at the time. Fish meal is still mostly imported in Zambia. As of 2017, one of the six feed companies interviewed in this study, ceased production, citing high competitiveness in the industry (i.e. too many feed suppliers and too few commercial farmers prepared to pay for feed; and a lack of a demand from small-scale farmers). In 2017, two new international companies (Skretting and Aller Aqua) finished building factories in Siavonga and are expected to produce an additional 75,000 mt of feed. These international firms have entered into contractual agreements with producers (Skretting with Lake Harvest Ltd. and Yalelo with Aller Aqua), which reveals the high level of coordination between lead firms.

### 4.6. Distribution, processing and retail

Farmed fish from the large-scale sector is transported in fresh/frozen form mainly to consumers in urban areas, with the majority going to Lusaka and the remainder to Copperbelt Province. Transport of fish to the final market is either managed through contracted logistics companies or through vertically integrated transport and retail operations. Most large-scale producers do not own distribution and retail functions, and therefore sell to commercial fish traders, such as Capital Fisheries Ltd., who supply cold store logistics and who conduct further value addition (e.g. filleting and packaging). Capital Fisheries Ltd. is also regarded as a “lead firm” and is a major player in dictating the market and prices of farmed and wild-caught fish products in Zambia. The company also imports horse mackerel from Namibia and farmed tilapia from China.

According to key informants, the price of commercially farmed

[14] All fingerlings distributed by development organizations in Northern Province come from Misamfu Aquaculture Research Station.

[15] It is likely that the farmers selling seed sourced it originally from the government stations or through previous development projects (Provincial DoF Officers pers. comm.).

[16] At the time of the survey there was an Irish Aid funded project in partnership with WorldFish and Self Help Africa that was distributing fingerlings to farmers in the same districts hence why these data may skew the percentages of people who received support from development institutions.

tilapia in Zambia was found to be only slightly higher than tilapia from wild fisheries, and at certain times of the year can be a cheaper source of tilapia because of the annual fishing ban on wild fish. Prices are often subject to unpredictable price fluctuations, based on a volatile exchange market and erratic capture fisheries supply.[17] Generally, farmed fish from the commercial sector is categorized into three different grades. 'Grade one' describes fish that weighs more than 300 gram (g), and is currently sold for 24–27 Zambian Kwacha (ZMW) (~$2.55 United states Dollar [USD] per kilogram [kg]); 'grade two' comprises fish of 100 g to 300 g and is sold at 18 ZMW per kg ($1.8 USD/kg); 'grade three' is fish of a weight less than 100 g and sold at around 8 ZMW per kg ($0.8 USD/kg). Prices were reported to reach a maximum of 28 ZMW per kg ($2.80 USD/kg) for domestically farmed fish and 22 ZMW per kg ($2.20 USD/kg) for imported tilapia of a similar size in 2016. Some smaller sized imported tilapia (100–200 g) can retail at 17.5 ZMW per kg ($1.75 USD/kg).

According to all key informants from production companies, farmed tilapia imports are said to sell at lower unit prices than domestically produced farmed tilapia but they are also generally of a smaller grade and size. The smallest grade tilapia produced by the domestic commercial sector is highly demanded by mostly women retailers who purchase fish from depots in Lusaka, Kitwe and Ndola (see Fig. 1) and distribute it to fish markets throughout urban areas, targeting low-income consumers. This is estimated to be around 5–10% of the total production of the large producers.

### 4.7. Fish imports

Data from the Zambian Revenue Authority show that Zambia imported 55,184 mt and exported only 136 mt in 2014. The data shows that in 2014, 68% of these imports came from Namibia, 20% from China and 11% from Zimbabwe, with the rest coming from several countries. Fish imports have grown 14-fold over a 10 year period between 2004 and 2014 (average increase of 30.47% per annum). When combined with population data from the CSO and the DoF production data for capture fisheries and aquaculture, the annual fish supply per capita rate has grown from 6.8 kg per person in 2011 to 11 kg per person in 2014 (see Fig. 3). However, these projections still retain the inflated production volumes for the small-scale sector presented in government reports and should be met with caution. Nevertheless, aquaculture and fish imports have both played a role in increasing fish supply albeit a significantly higher portion has come from fish imports. Without fish imports the supply per capita rate would drop by 3.9 kg.

An area of concern for all of the key informants involved in domestic aquaculture production (including feed and seed companies) was the competition that the Zambian aquaculture sector faces from imported fish, in particular farmed tilapia from China. There was a sudden increase in horse mackerel and tilapia imports in 2012, with no tilapia being imported before then. The majority of fish imports in 2014 was horse mackerel, mostly from Namibia, making up 64% of all imports. A further 12% was labelled as 'frozen fish' and 4% was made up of 'other products' such as lobster, mussels, oysters, scallops etc. Approximately 20% of total fish imports (11,141 mt) in 2014 was formally labelled as tilapia, 87% of which came from China, 7% from Hong Kong, 2% from Namibia, 2% from Vietnam and the rest coming from Brazil, India and South Africa.

Capital Fisheries Ltd., a major importer of farmed tilapia, state that they are able to find markets for both imported and domestically produced tilapia, with the former targeting lower-income areas and the latter targeting middle-income areas and large retailers (supermarkets) (Managing Director of Capital Fisheries pers. comm.). Several key informants stated that the importation of farmed tilapia from China is much higher than what is reported and that tilapia products are "dumped" in Namibia and being labelled as horse mackerel. The fear from several producers is that whilst large-scale domestic producers can grow their fish to sizes that can reach high-income markets, the importation of small-sized tilapia will impact smallholder farmers since these farmers still struggle to access commercial aquafeeds and grow large tilapia.

## 5. Discussion

There is clear evidence of growth in the aquaculture value chain in Zambia between the years 2004 and 2014. Whilst fish supply per capita is expected to decrease in Africa in the next decades, it is increasing in Zambia and aquaculture is playing a positive role. The growth of the sector has been achieved through a range of upgrading efforts made by private actors. Certain forms of coordination, particularly vertical integration of operations and different levels of contractualization have allowed for firmer relations and linkages between nodes and companies i.e. stronger partnerships, sharing of information, collaborating on product development, etc. The clearest example of this is the contractual relationships between producers and feed companies who collaborate to develop aquafeeds.

There is no published literature on upgrading in the Zambian aquaculture value chain and none for aquaculture value chains in Africa in general. Upgrading in Asian aquaculture chains has had some attention (Bush and Belton, 2012; Pham et al., 2011; Ponte et al., 2014) and we attempt to make some linkages with this literature and our study. In particular, the literature in Asia focuses on upgrading in response to pressure from international buyers that demand food safety and sustainability of farmed fish. According to Bush and Belton (2012) however, this provides incentives for upgrading only if it enhances market access and/or price, which is not always the case. Such demands are certainly not yet evident in African aquaculture value chains where incentives for upgrading mainly come from internal, domestic drivers. The sector in Zambia is particularly in its infancy and loose regulatory controls have created a pioneering environment with various commercial players attempting to gain competitive footholds in the value chain to supply domestic markets.

Most upgrading efforts can be attributed to what the government in Zambia calls the large-scale sector. These commercial farms, as well as large commercial upstream and downstream firms, have pioneered the development of commercial aquaculture by making specific upgrades, particularly in products and processes, and through successful coordination efforts between nodes.

All types of upgrading were found in our study of the Zambian aquaculture value chain. The introduction of fast-growing non-native species, the promotion of integration with livestock manure, the increasing diversification of species, and the integration of hatcheries and retail logistics, all of which have had significant impacts on the commercial sector by improving productivity and enhancing volumes. A major area for upgrading related to product, process and functional upgrading, has been the development of feed and seed inputs. The quality and optimal use of inputs in aquaculture is an important determinant for productivity, and therefore, improving quality (and availability) of inputs is a key objective for process upgrading. The incentives for these investments into inputs came from available capital and a gap in regulations on the importation of exotic strains before the 2011 regulatory controls. The Fisheries Act No. 22 in 2011 provided some regulations in terms of certifications, permits, zoning, environmental considerations, etc., which may have provided an impetus for the development of the sector in aquaculture zones such as in Siavonga on Lake Kariba. Whilst this was not in the scope of the paper, the enabling factors and the institutional framework require further research in order to understand the institutional drivers of aquaculture development in Zambia.

[17] Government data shows stagnation in fish supply from capture fisheries though research points to a decreasing trend in fish stocks and in the sizes of the fish species caught, especially Tilapiine cichlids (Tweddle et al., 2015; Kolding and van Zwieten, 2014).

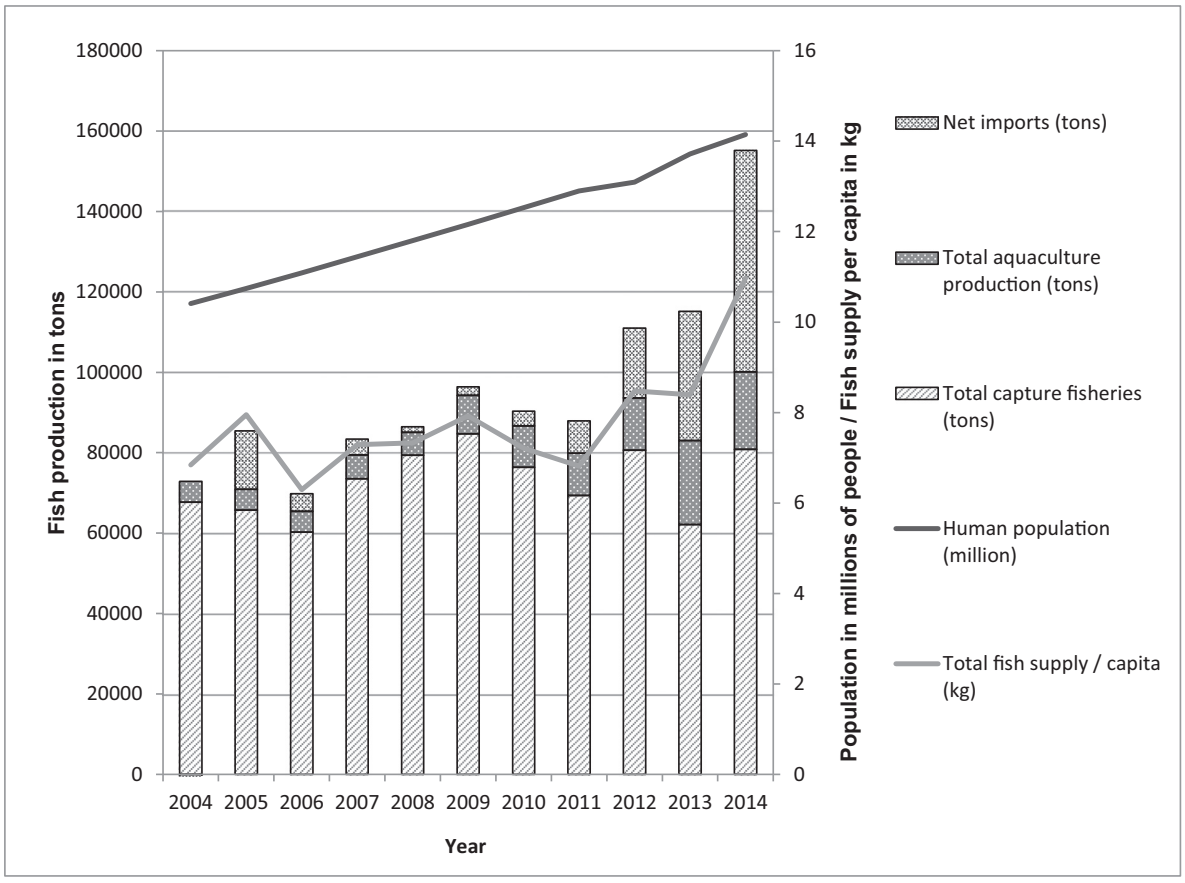


**Fig. 3.** Total fish supply per capita (2004–2014).
Source: Authors' compilation based on DoF production data, ZRA import data and CSO population data (2004–2014)

An example of product upgrading can be seen by Kafue Fisheries Ltd. changing to improved non-native strains, specifically *O. niloticus* broodstock imported from Thailand. Many commercial actors are targeting the top of the consumer pyramid by developing fish products of a larger size, and which thus need to grow faster. There is indication that market segmentation exists in Zambia, which allows for specific targeting of groups of consumers, as seen by the demand for smaller tilapia by mostly women retailers who distribute fish to lower-income areas in urban markets. There is no evidence however, of companies targeting these areas though small-scale farmers, who may struggle to access certain inputs, could aim to grow smaller-sized tilapia to target these groups. Further evidence of product upgrading is seen by some farms attempting to grow common carp to satisfy Asian expatriate markets. Some local filleting has also been established by Capital Fisheries Ltd., specifically targeting the urban middle class, however, the degree of sophistication of processing and the diversity of products is still limited compared to processing operations in Asia for instance. There is limited evidence of product upgrading trajectories related to food safety and product quality at farm level similar to what is seen in Asia under the influence of international pressures (see Ponte et al., 2014).

Evidence in this paper suggests that process upgrading is the most common, especially in terms of improved feeding regimes, access to higher quality feeds (as a result of tighter coordination between producers and feed mills), sex-reversal and improved animal husbandry and pond management, etc. Process upgrading in the feed sector is also evident with improved methods and technologies to develop aquafeeds. Zambia has recently seen the construction of the largest, state-of-the-art feed mill in Africa (Aller Aqua) and such upgrades are certain to have an impact on the sector.

Improvements in infrastructure and logistics for distribution and retail, in particular the emergence of integrated cold chains, albeit specialized logistics for large aquaculture farms, also make frozen and fresh tilapia products more available in markets that have traditionally been dominated by dried and smoked fish products (including wild-caught tilapia). Cold chains and logistics are either integrated into the operations of a company or are provided by large processing actors that have established cold chains across the country. Such specific logistical upgrades at company level are examples of functional upgrading taking place in some of the larger firms in the sector, adding functions both upstream (seed, feed) and downstream (distribution, retail). A *hierarchy* type of value chain (i.e. vertical integration) is a defining commercial trend and form of coordination that is shaping the value chain in Zambia. The data from key informants shows that vertical integration is mainly a risk management strategy, as companies gain more control over the quality of inputs and improve functionality of their downstream activities in the chain. This form of coordination in the value chain means intermediaries and smaller actors have to adjust their position and activities to the vertical integration strategies of larger firms.

Inter-chain upgrading seems to have been one of the first triggers for commercial fish farming in Zambia. In promoting integrated farming of pigs and fish, and crocodiles and fish in the 1990s, the Zambian government provided an opportunity for pioneering lead firms to develop some of the first commercial farms in the country. The integration between pigs and fish has worked remarkably well for Kafue Fisheries Ltd., which is one of the largest pond-based tilapia farms in Africa. Few other farms in the country have replicated this model and other examples of inter-chain upgrading (e.g. utilizing different species or further integration with other sectors) are not yet evident. Another example of inter-chain upgrading is seen by the existing Zambian feed

mills that utilized competencies and skills from producing poultry and livestock feeds into the development of aquafeeds.

There are upgrading options for the small-scale sector, such as improved farm management, producing own seed, and improved vertical and horizontal coordination for better access to markets and stronger collective farming models, however, farmers do not have incentives to invest in such efforts as aquaculture is mostly seen as a source of food for the household and not prioritized as a major income earning activity. Only 8% of the practicing farmers from our survey farmed fish as a primary income activity and 16% of the larger sample had abandoned production. Development organizations have been supporting upgrading efforts with limited success and mostly on a small, localized scale. The dependencies on government input supplies are evident in our small-scale farm survey, and such forms of coordination are largely sustaining the sector, with little evidence of improved growth. Whilst commercial farmers have been able to benefit from upgrading efforts they have had limited impact on the small-scale farmers who are located in provinces where non-native species are banned (for more detail see Simataa and Musuka, 2013) and where new feed products on the market are yet to penetrate. The small-scale sector has not been able to take advantage of the environment that is created by the large-scale sector. Overall, evidence from our sample of famers in Northern Province suggests that small-scale farmers are operating in isolation of commercial trends evident elsewhere in the country.

Finally, whilst Zambia has yet to make its mark on the exportation of farmed fish in the region, the increase of imported farmed tilapia products was revealed to be of great concern for many aquaculture stakeholders that took part in the study. It is evident that the importation of fish is playing a large role in the national supply of fish per capita and likely keeping the price of tilapia products relatively low and more affordable for poorer consumer groups. This provides justification for imports in terms of food and nutrition security in a country that still struggles with malnutrition (Longley et al., 2014), though little is known on the consumption trends of these fish. It remains to be seen how the government will prioritize the domestic development of aquaculture with the food and nutrition security of the population. Further research into the effects of fish imports on production and consumption is desperately required for Zambia and elsewhere in Africa.

## 6. Conclusion

This paper aimed to examine the recent growth in the aquaculture value chain in Zambia under a GVC analysis. To understand this growth the study analyzed all nodes and segments in the value chain using primary (quantitative and qualitative data) and secondary sources. The findings show that the aquaculture sector in Zambia has significantly grown in the last decade, mainly due to upgrading trajectories in the commercial large-scale sector. Production from smallholders has remained mostly stagnant, despite significant efforts from development organizations and government. Actors within the large-scale sector have invested in significant upgrades in products, processes and function, borrowing also from competencies in other chains. Many of these companies have developed tighter relations between nodes and firms in the chain. Vertical integration seems to be a critical strategy for many firms to exercise more control over the value chain. Small-scale farmers meanwhile are not producing the amounts presented in government statistics and a clear lack of inputs; markets and general extension support seem to be the largest constraints to the sub-sector. A more thorough analysis of the rural, small-scale farming sector is required to understand the current status and trajectory of the sub-sector in the Zambian aquaculture value chain. With the production and availability of new input supplies (seed and feed mainly) and the development of cold chains and wholesale/retail logistics and markets, it is hoped that the small-scale sector can integrate further into the value chain rather than becoming more isolated. Whilst the chain is still in its infancy, a potential barrier to this inclusion could be the increasing importation of tilapia. For now, volumes in commercial aquaculture and imports have been rising simultaneously, however, many concerns are raised in the domestic sector on the long-term effects of imports. The increasing commercialization of aquaculture in Zambia provides a unique example of some of the emerging trends in aquaculture value chains in sub-Saharan Africa. It is critical to next analyze the institutional framework and enabling factors that have led to some of these developments.

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