



## INNOECOFOOD - Eco-innovative technologies for improved nutrition, sustainable production and marketing of agroecological food products in Africa

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#### Scoping for Aquaculture Practices in six African Countries

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## 1. Summary

One of the major goals of INNOECOFOOD is to conduct scoping of community knowledge, attitude and aquaculture practices in local lakes and rivers (living labs) and establish four sustainable and innovative agribusiness rural EcoHubs using renewable energy for the production, processing and marketing of aquaculture value chains (fish and Spirulina) and insects in diverse African countries (WP2), to address AU and EU green deal and trade. In line with this, the current deliverable is set to scope aquaculture practices in selected lakes and rivers in Kenya, Ghana, Tanzania, Egypt, Namibia and Uganda.

## 2. Kenya

### 2.1 Introduction

Aquaculture production in Kenya is currently at 31,655 million tones (MT) (Fig. 1), contributing only 0.6% to the national GDP (KNBS, 2024) and comprising freshwater aquaculture and mariculture. Freshwater aquaculture involves cold and warm water culture. Cold water species cultured are Rainbow trout (*Oncorhynchus mykiss*) and brown trout (*Salmo trutta*) in the Mount Kenya region, while warm water fishes comprise of Nile tilapia (*Oreochromis niloticus*) constituting 80% of the fish cultured, African catfish (*Clarias gariepinus*), and other species comprising 20% (Opiyo et al., 2018). The two species, Nile tilapia and African catfish, are mainly cultured as either monoculture or polyculture with integration of other farm activities like crop and livestock farming (Opiyo et al., 2018). On the other hand, mariculture involves the farming of finfish [Milk fish (*Chanos chanos*) and Grey mullets (*Mugil cephalus*)]; shellfish [(Mud crabs (*Scylla serrata*), oysters (*Saccosterea cucullata*), shrimp (*Penaeus monodon*)], and seaweeds (mainly *Kappaphycus alvarezii*) (Mirera, 2011; Munguti, Kim, et al., 2014). Mariculture is underdeveloped mainly due to accessibility problems, conflicts over land ownership, and lack of clear policies (KeFS, 2022).

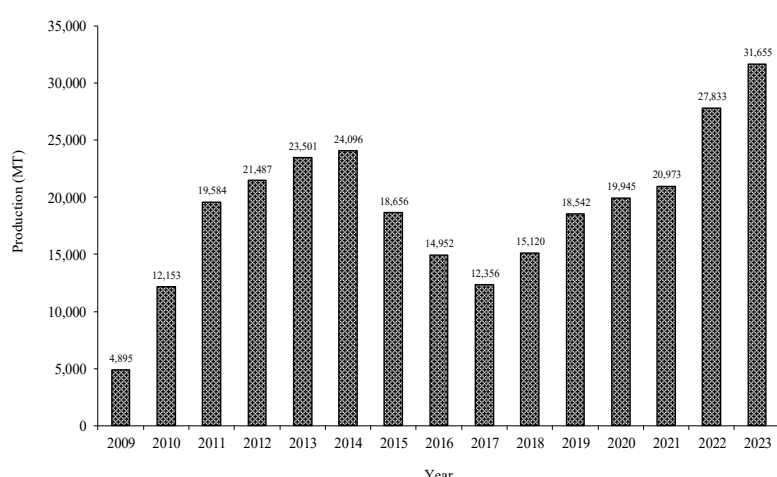


Figure 1. Aquaculture production in Kenya (metric tonnes, MT) trends between 2009 and 2023. Source:(FAO, 2016; KNBS, 2024).

Despite the increasing trend of aquaculture production, there is still a gap between fish production locally and the increasing demand for food fish, leading to Kenya importing about 5,900 MT annually from other countries such as China, India, Pakistan, Japan, Korea and Uganda (State Department of Fisheries (SDF), 2013).

Freshwater aquaculture in Kenya started in 1920's and became popular in 1960's. However, it stagnated until 2003 when the production rose from 1,000 MT to 4,000 MT, following numerous efforts to boost production through the "Eat More Fish Campaigns" championed by the government (FAO, 2016). Between the years 2006 and 2009, aquaculture production remained below 4,895 MT until 2010 when 12,153 MT was realized (Fig. 1) and it continued growing following numerous government efforts, especially the government nationwide Economic Stimulus Project - Fish Farming Enterprise Productivity Program (ESP-FFEPP), which for the first time, received substantial funding triggering a rapid growth in the sector (Musa et al., 2012; Rothuis et al., 2011), and supported fish farmers by subsidizing fingerlings, feed and pond construction. The support included construction of ponds in most parts of the country after mapping areas which were suitable for aquaculture (Fig. 2). Areas with high suitability were recorded at 9,581,169 ha, areas with medium suitability at 40,557,196 ha, whilst the areas of low suitability (mainly the arid and semi-arid lands (ASAL) regions of the country) at 3,242,515 ha (Fig. 2) (Ogello & Munguti, 2016). The ESP-FFEPP was implemented within the 2009 and 2013 financial years, leading to an increase in fish pond area from 220 ha in 2008 to 468 ha in 2009 and a total gross land for aquaculture from 728 ha (2008) to 825 ha (2009) (Obwanga et al., 2017).

It is evident that aquaculture production in Kenya reduced from 24,096 MT in 2014 to 18,656 MT in 2015 and further to 14,952 MT in 2016 (Fig. 1) (Obwanga et al., 2017). Similarly, the number of operational fishponds reduced from 69,194 (2013) to 60,277 (2015), shrinking the operational area from 2,105 to 1,873 ha in 2013 and in 2015 respectively (Ogello & Munguti, 2016; State Department of Fisheries (SDF), 2016). Reduction in fish production was as a result of poor water retention capacity of ponds in some counties in ASAL areas, poor extension services, inadequate capacity support, poor husbandry practices, low quality and quantity of fish farm inputs, poor marketing infrastructure and lack of value addition. The drought experienced between 2016 to 2017 also led to many farmers dropping from fish farming due to lack of water. Additionally, the establishment of county governments and subsequent removal of aquaculture from the functions of the national government to county governments also led to a reduction in aquaculture activities in several counties in Kenya which lacked support programs for fish farming (State Department of Fisheries (SDF), 2016).

The distribution of aquaculture production in Kenya is mainly high in Counties who received further support from the Aquaculture business development project ABDP which has spurred aquaculture growth in 15 counties in Kenya. Aquaculture production has been reported to be high in Kakamega, Kisii, Kiambu and Meru counties for pond-based aquaculture and Homabay, Kisumu and Siaya counties for cage-based aquaculture with large commercial farms like Victory farms producing 10000 MT of tilapia annually (Business Daily, April, 2023) (Fig. 2).



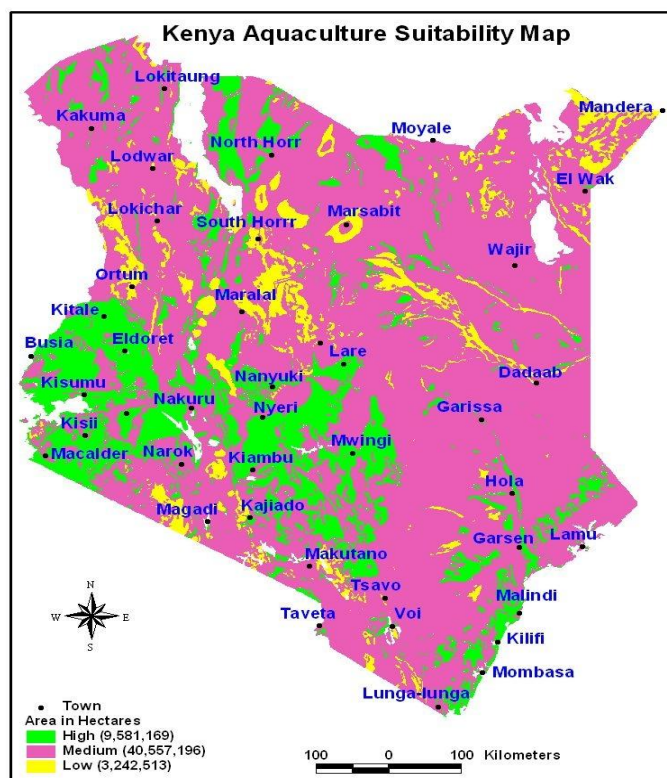


Figure 2. Map of Kenya indicating areas suitable for freshwater aquaculture: green, highly suitable, pink, medium suitable and yellow, low suitable aquaculture areas based on water availability, climatic conditions, soil type, topography, land use, access to inputs and markets: Source: (<https://www.ajol.info/index.php/ajfand/article/view/149194>) (Ogello & Munguti, 2016).

## 2.2 Aquaculture production systems in Kenya

Aquaculture production systems are made up of extensive and semi-intensive systems. Truly intensive systems exist in a relatively small number. Reports indicate that fish farmers operating at a subsistence level are turning into commercial intensive fish farming with some earning as much as US\$ 11,000.00 ha<sup>-1</sup> year<sup>-1</sup> in gross income (Mbugua, 2008). More than 70% of farmers practice extensive and semi-intensive fish farming while the intensive system is practiced by only 30% due to high cost of electricity and non-availability of cheaper quality feeds (FAO, 2016). In the semi-intensive systems, ponds are fertilized with either cattle, sheep, poultry or rabbit manure and supplementary feed in form of cereal bran (wheat, rice, maize) and low protein formulated feeds are given to supplement natural foods (Musa, et al., 2014). Aquaculture farm systems in Kenya are in most cases integrated with either crop or livestock production (vegetables, bananas, goats, cattle and chicken) (Ogello et al., 2013).

### 2.2.1 Extensive fish farming

This system is mainly conducted in dams and water reservoirs. The farmed fishes depend on primary productivity of the culture water and no artificial feed is given. The species mainly cultured in this system

are *O. niloticus* and *C. gariepinus* which are stocked to prevent breeding of mosquitoes in dams put in place for watering livestock. The dams are mainly found in Central and Rift valley regions. Production from this system ranges between 500 and 1,500 kg ha<sup>-1</sup> year<sup>-1</sup>, contributing 10% of farmed fishes in Kenya (Ngugi et al., 2007), but they have bigger potential of 72,894 t carrying capacity (Aura et al., 2022).

### 2.2.2 Semi-intensive fish farming

Semi-intensive farming is the main system adopted in Kenya. These systems are mainly used to produce *O. niloticus* and *C. gariepinus* either in monoculture or polyculture. They consist of earthen ponds, liner ponds and concrete ponds (Fig. 3). Ponds are fertilized using organic manures (cow dung, sheep, poultry or rabbit manure) (Munguti, Musa, et al., 2014). Feeding is done using supplementary feeds formulated on farm or purchased from cottage fish feed production industries. In some cases, cereal brans are used as feeds to increase pond productivity. Production from this system ranges between 1,000 and 2,500 kg ha<sup>-1</sup> year<sup>-1</sup> (Ngugi et al., 2007). Most farmers prefer this system since it is less expensive in terms of feed inputs.



Figure 3. Semi-intensive pond system.

The semi-intensive systems are largely excavated ponds which are either earthen or liner ponds. Most of small holder farmers have a minimum of 1 pond to a maximum of 60 fishponds. The level of operations of farmers are rated as small scale, medium or large scale (Obwanga et al., 2017). Large scale operators represent a pond surface area of 4,000 – 80,000 m<sup>2</sup> and more than 13 ponds, while medium scale operators represent 601 – 3,999 m<sup>2</sup> and 5 – 12 ponds. Small scale farmers have less than 5 ponds and in most cases use their own individual labor to produce fish mainly for household consumption and excess fish are sold to neighbors (Ngugi et al., 2007; Obwanga et al., 2017). A stocking rate of 3 fish m<sup>-2</sup> is commonly used in ponds in Kenya to achieve yields of 1 kg m<sup>-2</sup>. At this stocking rate daily weight gain ranges from 1.5 to 2.0 g in well managed systems. Rare cases in Kenya have stocking densities of 6 juveniles m<sup>-2</sup> in ponds giving a production of 3 kg m<sup>-2</sup> (FAO, 2016).

Most fish farmers practicing pond culture add manure or inorganic fertilizer to ponds to increase the supply of natural food organisms to fish so as to reduce production costs arising from feeds (Mbugua, 2008). The manures in use are cow dung, sheep, poultry and rabbit manure. Culture periods of 6 months or more are needed to produce fish that weigh between 250 to 300 g from the ponds. The size of fish attained at the end of the growth period depends on the climatic conditions of the area, especially temperature, with areas having an average temperature lower than 25°C having smaller fish at harvest. Type of feed used and management practices like water quality management, feeding regimes and stocking density also affect the growth of fish.

### 2.2.3 Intensive fish farming

#### Recirculating Aquaculture Systems (RAS)

Recirculating aquaculture systems in Kenya are mainly tank-based systems used for culturing *O. niloticus* and *C. gariepinus*. Fish are reared in tanks indoors or under green houses. There are 8 farms operating recirculating systems in the form of hatcheries and grow-out farms in Kenya. Fish are grown at high density ranging between 5 to 20 fish m<sup>-3</sup> under controlled conditions. Production from RAS is at 200 tonnes ha<sup>-1</sup> year<sup>-1</sup> (State Department of Fisheries (SDF), 2016). The adoption of the system is low due to high cost of initial capital investment in tanks, greenhouses and high cost of electricity required in running the system. Investment in recirculation aquaculture systems (RAS) for Nile tilapia production and intensive catfish production is carried out in peri-urban areas near towns like Nairobi, Kiambu, Nyeri, Meru, Kisumu, Machakos, Kilifi, Homa Bay, Kakamega and Busia (State Department of Fisheries (SDF), 2016).



Figure 4. RAS system in Kamuthanga fish farm (top) and catfish production at Makindi farm (bottom).

#### Cages

Cage farming is growing fast in Lake Victoria with the highest number of cages located in Siaya County (Aura et al., 2018). Cage farming is practiced in five riparian counties (Migori, Siaya, Homabay, Busia and Kisumu counties). Stocking density in cages ranges between 60 to 250 fish m<sup>-3</sup> with cage sizes ranging from 8 to 200 m<sup>3</sup> (Obiero et al., 2022). The number of cages increased from 1,663 in 2016 to 4,347 in 2021 (Njiru et al., 2019; Okechi et al., 2022). Nile tilapia is the only fish cultured in cages estimated to produce 12,000 tonnes annually (Aura et al., 2018; Njiru et al., 2019) (Fig. 5).



Figure 5. Cages in Lake Victoria

## 2.3 Husbandry practices

### Feeds inputs

Various feeds are used by fish farmers in Kenya, ranging from mash (for fingerlings) to farm made pellets, pressed pellets (made locally by a number of companies) and extruded floating feeds (Fig. 6). Extruded floating feeds are mainly imported from other countries including, the Netherlands, Norway, Denmark, Israel, Mauritius, Uganda and Ghana (Munguti, Kim, et al., 2014; Munguti, Musa, et al., 2014). Companies producing extruded pellets in Kenya are Tunga (nutreco group), Sigma Ltd, Unga Feeds Ltd, Lenalia Feeds Ltd (Munguti, Kim, et al., 2014). Due to unavailability of cheaper feeds in the country, some farmers have been using pig pellets and poultry feed (grower and layer mash) to feed fish (Jacobi, 2013; Liti et al., 2005). The use of pig or poultry feed for fish is not recommended since fish and other livestock have different dietary requirements for efficient growth (National Research Council (NRC), 2011). This implies that fish get nutrients in proportions, which are limited leading to wastage of feed, and poor growth.



Figure 6. Commercial feed available in Kenya (aller aqua, Skrettings, Raanan).

### Fish seed inputs

Fish seed is sourced from hatcheries which are either owned by the government or private farmers. Between the years 2010 to 2016, the government owned National Aquaculture Research and Development Training Centre, Sagana, that supplied 30.3 % of fry and fingerlings, while private hatcheries contributed with 69.7 % (Nyonje et al., 2018; State Department of Fisheries (SDF), 2016). The total demand for both African catfish and tilapia fingerlings across Kenya was estimated at 100 million yr<sup>-1</sup> in 2010 (Musa et al., 2012). The common methods used in Kenya for fingerling production are open ponds, tanks and hapas in ponds. Fry are collected from the spawning units at 0.03 to 0.05 g and stocked into nursery units for rearing to the fingerling stage (5 g) before they are stocked into grow out facilities (Nyonje et al., 2018) (Fig. 7). Currently, there are a total of 127 authenticated hatcheries in Kenya with a capacity to produce 96 million fingerlings annually (Nyonje et al., 2018). On average, the hatcheries record a survival of 70% of the hatched crop which are sold to farmers at fry or fingerling stage (Musa et al., 2012). The hatcheries are in different parts of the country to allow for ease of access by farmers (Nyonje et al., 2018; State Department of Fisheries (SDF), 2016). The fingerlings for Nile tilapia produced include all male tilapia produced through sex reversal, naturally male tilapia produced by the use of super YY males and mixed sex tilapia fingerlings (Nyonje et al., 2018).



Figure 7. Catfish fingerlings

## 3. Ghana

### 3.1 Introduction

Ghana is considered one of the highest fish consuming countries in sub-Saharan Africa with a per capita fish consumption of 26 kg (Asiedu et al., 2017), which is more than the World average of 20.3 kg and 10 kg for Africa. Fish constitutes 60% of animal protein intake of Ghanaians as compared to 15% at the global level (FAO, 2014). However, domestic production of fish is about 451,000 t while annual domestic demand for fish is above 1 million tonnes (MoFAD, 2016), leading to persistent importation of fish to cater for the deficit. This has led to the promotion of aquaculture by both governmental and non-governmental agencies (Ansah, 2014), due to its numerous benefits. Over the past decade, Ghana's aquaculture has experienced tremendous growth in production, contributing to improved incomes and livelihoods (Ragasa et al., 2018). In 2018, the sector produced 76,600 MT of farmed fish valued at US\$200 million. The Nile Tilapia, *O. niloticus* accounts for about 90% while catfish and other culturable fish contribute nearly 10% (Fig. 8). Since 2018, Ghana has become the largest producer of tilapia in Sub-Saharan Africa (SSA), second only to Egypt on the African continent. Among African countries, Ghana's aquaculture grew the fastest, at an annual rate of 28% from 2006 to 2019. Because this growth was driven mainly by large-scale cage farming around Lake Volta, much of the investment and research have focused on cage farming, although most micro- and small-scale farmers are involved in pond farming.

The legal Nile Tilapia strain for culture in Ghana is the Akosombo strain developed by the Aquaculture Research and Development Centre (ARDEC) of the CSIR-Water Research Institute of Ghana. In recent times, catfish production is increasing and is projected to further increase in production volumes by 20% as more fish farmers are diversifying into catfish production for various reasons including ease of culturing catfish.

### 3.2 Aquaculture production systems in Ghana

Fish production systems used are mainly floating fish cages, accounting for the highest quantity of fish culture production. Cage farms account for less than 2% of farms by number but farmed fish from floating cages on the Lake Volta contributes between 75% and 93% of overall aquaculture production in the country (FAO, 2018). Tilapia production in Ghana mainly along the Lake Volta has developed rapidly as a commercial activity, with 73% growth rate annually and contributes up to 90% of the overall aquaculture production (Rurangwa et al., 2015). Tilapia is the most preferred and highly demanded freshwater fish in Ghana and there exists ready market locally for all sizes of tilapia (MoFAD, 2014). Tilapia is mostly preferred for culture due to its relative advantages such as resistance to diseases, easy to confine and tastiness.

Production of catfish in cages are emerging with production levels being less than 5%. However, there are several earthen ponds for inland culture of tilapia and catfish (Fig. 10), though the production capacities of these ponds have not been fully realized. Thus, most of these ponds have become rendered unproductive and unprofitable to operate. Other emerging production systems used in catfish production on a small scale are the tarpaulin tanks and, in some cases, concrete tanks or ponds (Fig. 11). Some of these systems run on the recirculatory aquaculture systems (RAS). Few aquaponics and biofloc technology systems are being practiced in urban homes and on some commercial farms for tilapia production.





Figure 8. Nile Tilapia, *Oreochromis niloticus* (Akosombo strain) (left), and Catfish, *Clarias gariepinus* after a 6-months culture period in Ghana (right).



Figure 9. Floating fish cages for Tilapia production in Ghana.



Figure 10. Earthen ponds with monk structure for catfish and Tilapia production in Ghana.



Figure 11. Concrete tanks for Tilapia and catfish production.

### 3.3 Husbandry practices

Aquaculture husbandry practices in Ghana are evolving, but the rate of adoption is quite slow. Fish are often reared in the same culture system from the fingerlings stage to the marketable (table size) fish. Most fish farmers depend on low fish stocking densities, use of old methods of production in small production systems such as earthen pond, no or low physical and biosecurity measures, supplementary feeding with low nutritional raw material from domestic by-products, poor feeds and feeding once or twice daily in most cases.

Major challenges for Tilapia and catfish production include the high cost of tilapia and catfish feed, inadequate funding/credit facilities for expansion, poor biosecurity causing fish health issues, complex permit and licensing regime, poor compliance and enforcement of aquaculture regulations, few alternative fish products on the market and natural disaster among others.



## 4. Tanzania

### 4.1 Introduction

Aquaculture in Tanzania marked its initiation back in 1949 when the rainbow trout (*O. mykiss*) were introduced in the Northern and Southern Highland regions by missionaries. Since its start in the country, the sector has undergone various phases of expansion and decline. Until now, its contribution to the economy and food security is still low. Currently, the aquaculture sector hosts about 34,417 fishponds, and 1,225 cages, with 85% being installed in Lake Victoria in 2023 (URT, 2024). In 2019, tilapia and catfish production were at 16,288 MT per annum, contributing only 2% of total production (URT, 2019). Most freshwater fish farmers in the country are of small scale, who stock their fingerlings at 3 fish m<sup>-2</sup> stocking density. The majority of fishponds are found in the Southern highland regions including Ruvuma, Njombe and Iringa, mainly due to plenty of availability of water from streams in the region (Rukanda 2016; Mulokozi et al., 2021). The average fishpond size is 300 m<sup>2</sup> (15x20 m) (Fig. 12). Over 95% of the farmed freshwater fish is tilapia, with the remaining 5 percent being catfish (Mulokozi et al., 2021).



Figure 12. Example of the commonly used fishponds in Tanzania

### 4.2 Aquaculture production systems in Tanzania

#### 4.2.1 Extensive fish farming

Extensive aquaculture systems are usually found in more remote areas, where fishponds are located far from residential areas (Rukanda Mulokozi et al 2021). Due to poor management, the ponds usually contain mud, grasses and flocked inlets and outlets, and production from these systems are normally very low (Fig. 13).



Figure 13. Typical example of extensive fishponds in Tanzania.

#### 4.2.2 Semi-intensive fish farming

The majority of aquaculture systems are semi-intensive whereby farmers are considerably managing the farms (Fig. 14). In semi-intensive systems, ponds are fertilized with either cattle, sheep, poultry or rabbit manure and supplementary feed in form of cereal bran (wheat, rice, maize) and low protein formulated feeds are given to supplement natural foods (Mulokozi, 2021). Between 2005 and 2019, the semi-intensive ponds increased from 13,000 to 27,000 (Fig. 14), and currently the number stands at 34,417 ponds (URT, 2020; URT, 2023). The rapid growth has been shown also in urban and neighboring areas such as Dar Es Salaam and Coast, where people are investing in semi-intensive culture systems, hatcheries and feed production.



Figure 14. Example of semi-intensive fishpond system in Tanzania.

### 4.2.3 Intensive fish farming

#### Cage farming

Experimental cage farming in Tanzania started in 2013 with a study to test the effect of different stocking densities of Nile tilapia on growth, survival, Food Conversion Ratio, and impact on water quality (Rothuis et al., 2011). Currently, the aquaculture sector hosts over 4,000 cages and expects to increase dramatically in the near future, with 85% being installed in Lake Victoria in 2023 (URT, 2024). The cage farming usually involves stocking of Nile tilapia at a stocking density ranging between 50 to 150 fish m<sup>-3</sup> after 6-9 production cycles, depending on the targeted market. Lower stockings normally produce fish with bigger sizes, which have greater market price in big cities like Dar es Salaam, Dodoma and Mwanza. The smaller fish from high stocking practice are plentiful in markets nearby cage farms in Mwanza town. There is no report of other fish species than tilapia being involved in cage farming. The common cage size is 5m x 5m x 5m (Fig. 15) with square shapes, made of steel material (URT, 2024).



Figure 15. Commonly used fish cages for farming tilapia in Lake Victoria, Tanzania.

#### Recirculate aquaculture systems (RAS)

There is growing interest on urban aquaculture systems such as aquaponics and Recirculated Aquaculture System (RAS) that use less water and space. Due to various reasons including the high capital and technological challenges, the systems are not yet practiced in Tanzania. RAS systems are currently only operated for experimental purposes and case shown in different exhibitions for demonstration (Fig. 16).



Figure 16. Example of demonstrational RAS system at SUMA JKT, Tanzania.

### 4.3 Husbandry practices

#### Seeds (fingerlings) production and management

Fish seeds are produced by both the government and private sectors using outdoor and indoor hatcheries. The indoor hatcheries usually have simple technology involving fish tanks, glass hatching jars and pipes. Tilapia brooders are placed in happa fitted in ponds to enable easy egg collection. Eggs are collected from the mouth and taken to the hatchery for hatching. The hatched fry is then fed with feed mixed with male hormone to produce monosex fingerlings. For the outdoor fish hatchery, fish parents (brooders) are stocked in different stockings based on fish species i.e. from 4 fish per m<sup>2</sup> for Tilapia to 7 fish per m<sup>2</sup> for Catfish (Rukanda 2016). The fish in the pond are allowed to breed and collection of fingerlings is done. The female-male fish sex ratio of the brooders is usually 3:1 in ponds. The fingerling price differs depending on the source, with tilapia fingerlings being sold for 100 Tsh (1 Tsh = 0,00033 EUR) at government hatcheries, and 200-300 Tsh at private hatcheries, whereas Catfish is sold for 250 Tsh at government hatcheries, and 400-500 Tsh at private hatcheries.

#### Feed Production and Management

Fish feed production in Tanzania varies from home-made to commercial feeds from both local producers and importation. The commercial producers produce powdery and pelleted fish feed (Mulokozi et al., 2021). Feed produced within the country uses local raw materials, which includes cassava flower, rice bran, sunflower oil, fish meal, soya bean meal, sunflower seed cake, blood meal, seafood cuttings and offal. There is great fluctuation in the availability of the feed raw materials (Rukanda, 2016). For example, agricultural inputs are highly available during the harvesting season (May-July). Fish meal is available in the sardine peak harvesting time, i.e. during inter- monsoon winds (March-April and November-December). The price of 3,000-5,000 Tsh kg<sup>-1</sup> for the formulated feed from commercial producers is high for most fish farmers (90% of total farmers).

#### Management practices

Fish seeds are either mixed (for both tilapia and catfish) or monosex (all male) Tilapia. The fingerling price varies between government and private owned hatcheries, with fingerling from government being cheaper

than those from private hatcheries. Tilapia fingerlings are lower in price due to their convenience in production compared to catfish. Farmers who cannot afford purchasing fingerlings from hatcheries usually obtain their fish seeds from the wild or from their neighbor farmers.

### **Fish feeding and management**

Fish in the grow out phase, which takes 6-9 months, are usually fed on natural food, or supplemental feeds obtained from producers or homemade feeds depending on scale of production. At the age of 1-2 months, fish are fed with fish powdery feeds and with pellets when they reach over 3 months. Due to the high cost of floating pellets (3,000-5,000 Tsh kg<sup>-1</sup>) most farmers use powdery homemade feed throughout the culture period (Rukanda, 2026).

### **Water quality management**

The majority of farmers monitor the water quality of their fishponds by sight observation or palm deeping and do not use water quality measuring kits. In some areas fish are challenged with water shortages due to droughts, especially during the dry season. There is limited knowledge on disease control among farmers, luckily there hasn't been any disease outbreak incident reported (Mulokozi et al., 2021).

### **Harvesting, storage and market**

Fish (tilapia and catfish) harvesting is usually done by totally harvesting or partially using seine nets and gill nets. The use of cold storages like cold rooms, ice, among others, is not common because most farmers are located in remote areas with low levels of economy and limited access to electric power, thus exposing them to post-harvest loss problems. Fish are sold either on farm or neighbor fish markets and the price for one kilogram of fish ranges between 6,000-10,000 Tsh for Tilapia, and 5,000-8,000 Tsh for Catfish.



## 5. Egypt

### 5.1 Introduction

Aquaculture in Egypt is an important source of animal protein. The Egyptian aquaculture industry has expanded rapidly in the last two decades, from producing 139,389 tons of farmed fish in 1998 to 1,561,457 tons in 2018 (FAO 2003–2020). This increase was achieved through a paradigm shift from traditional extensive to semi-intensive fish production and modern intensive aquaculture systems supported by the Egyptian government policies and growing private investments (Shaalan et al., 2018; Adeleke et al., 2020a). As a result, Egypt now ranks as the top aquaculture producer in Africa (accounts for 71% of the continent's output) and a major global aquaculture powerhouse (Shaalan et al., 2018; FAO, 2016). Importantly, Egypt is the third largest tilapia producer globally (after China and Indonesia), with tilapia aquaculture playing a significant role for the national economy and food security (FAO, 2020a, FAO, 2020b; Nasr-Allah et al., 2020), as all the national output is marketed locally (Shaalan et al., 2018). Catfish represents only 0.54% (8,475 tons) of production. Most fish farms in Egypt are in 5 governorates (Kafr El-Sheikh, Eastern Lake, Behera, Port Said, and Damietta).

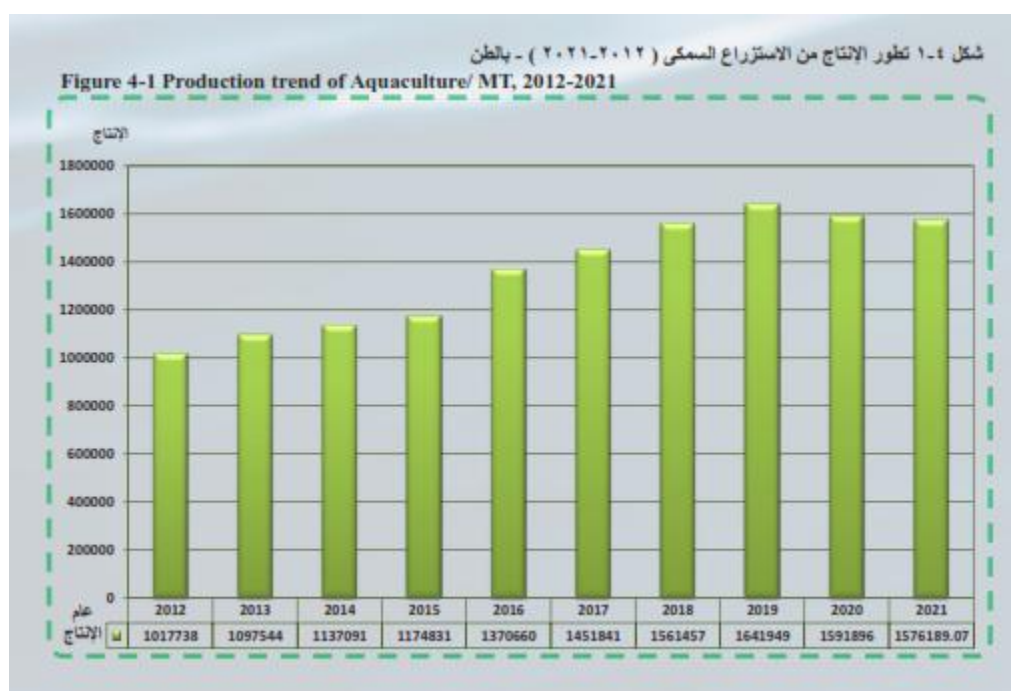


Figure 17. Production trend of Aquaculture in Egypt.

The major tilapia species in Egypt are four: Nile Tilapia (*O. niloticus*), Blue Tilapia (*O. aureus*), Tilapia Zillii (*Coptodon zillii*) and Tilapia Galilea (*Sarotherodon galilaeus*). The Nile tilapia is the most common species in Egypt due to its excellent taste and reasonable price. It is also preferred among farmers because of its fast growth, tolerance to adverse environmental conditions, and mode of reproduction.

At the retail level, aquaculture products are sold alongside wild-caught products. There are currently no regulations requiring the origin of fish to be identified by retailers and whether they are farmed or wild fish. The marketing system for fish is simple but efficient, as the fish are auctioned daily (Fig. 18). Farmers also

have agreements with wholesalers who purchase their harvest directly from the farm site. Agreements are usually informal, and in many cases the wholesaler finances the production operations and receives the harvested fish at a price agreed in advance. Aquaculture products tend to be consumed in the domestic market, as Egypt only exports about 28,066 tons.



Figure 18. Public fish market in Egypt

Tilapia fry is produced in more than 900 hatcheries, accounting for 157.7 million monosex fingerlings for cultivated area, which is about 3,490-hectare of governmental farms and 108,665-hectare of private farms. Regarding catfish, there are a few catfish farms, with a pond area of 0.5 hectare and with a density of 4–6 thousand for acre and a production of 6-10 tons. Many tilapia farmers stock catfish with tilapia (1,500 catfish with 15,000-20,000) per acre (about 4,200 m<sup>2</sup>). Catfish fingerlings average weight is from 40 to 50 grams, and the harvest weight is about 1-2 kg after 8 months. There is no specific feed for catfish, therefore, many farmers use tilapia feed or trash fish.

## 5.2 Aquaculture production systems in Egypt

There are many aquaculture systems in Egypt that depend on the area, water availability and target production size. Beheira, Kafr El-Shiekh and Sharqiyah fish farmers depend on semi-intensive systems, but in a new agricultural area in the desert, where the availability of water is low, they depend on integrated systems and intensive systems.

### 5.2.1 Extensive fish farming

This system is considered one of the simplest methods used for aquaculture. The density of fish in the ponds is low. From 1 to 4 fish per m<sup>2</sup>, fish in this system depend on the natural food available in ponds. The fish are not provided with any additional food, and natural food includes everything suspended and floating in the water of living organisms of plant origin (Phytoplankton, including bacteria, blue-green algae, green algae, and others). Or zoonotic (zooplankton, including "Daphnia" and cyclops), which is considered the main feed item for fish larvae. It constitutes natural food for some small fish, along with bottom worms, insects, and their larvae. Aquatic plants and many herbs, weeds and algae are also food for large fish. This old system was used in the 70s and early 90s, but it is not used at present in Egypt.

## 5.2.2 Semi-intensive fish farming

This is considered the common system in Egypt. The fish density in this system is higher than in the extensive system, and fish are stocked in ponds with large areas ranging from 8 to 15 acre per farm. The fish's density increased by 10 to 20 kg m<sup>-2</sup>.

## 5.2.3 Intensive fish farming

This system has recently begun to spread in Egypt in various forms, based on providing a balanced diet rich in protein that meets the nutritional requirements of fish according to different ages. High densities of fish are placed in ponds (20–30 kg m<sup>-3</sup>). There is also great reliance on operating ventilation systems continuously and constantly changing and reusing water (Fig. 19). Only 1,911 tons of tilapia are obtained from intensive systems, and 72 tons are catfish.

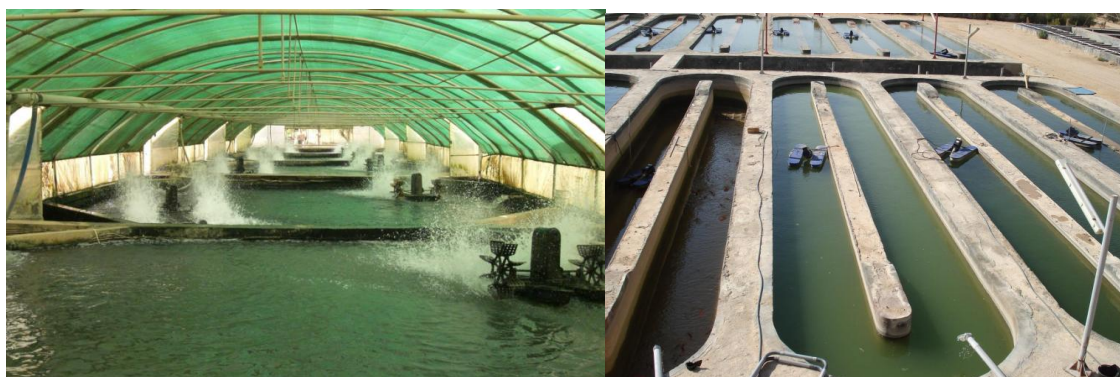


Figure 19. Intensive systems in Egypt.

### In Pond Raceway Systems (IPRS)

The first IPRS system was developed at WorldFish's facility in Abbasa for tilapia aquaculture (Fig. 20). The system is made up of cells, which occupy about 2% of the basin area. The cells are used as fish containment units, while the remaining open space of the pond is used as a waste gas treatment area. All cells are equipped with airlift/white water units to aid continuous water movement and aeration during the production season and barriers to allow full circulation of water in an earthen pond before re-entering the raceway cells again. To meet the increasing pressure on water availability in Egypt, using IPRS for tilapia production improves water use efficiency in fish farming. Fish solid waste is collected to be used as fertilizer input, reducing global gas emissions from fish farming.

The production of IPRS system from tilapia is 65 tons and is established in Beheira, Kafr El-Shiekh , Sharqeia and Giza governorates.



Figure 20. In Pond Raceway Systems (IPRS) – abbassa – abo hamad – Sharqeia.

### Biofloc System

Biofloc provides two critical services—treating wastes from feeding and providing nutrition from floc consumption. Biofloc systems can operate with low water exchange rates (0.5 to 1 percent per day). This long water residence time allows the development of a dense and active biofloc community to enhance the treatment of waste organic matter and nutrients. This system is relatively new to Egypt. Only three farms in Egypt have begun using this system (Fig. 21).



Figure 21. Biofloc System in Egyptian desert.

### Integrated fish farming

This system allows farms to produce more than one crop at the same time. The farm is used to produce vegetable crops and fish; the exchanged water that comes out of fishponds is used to irrigate crops/vegetable production. Fish can be cultured in rice field channels, and this has been used since the late 1990s. It contributes to raising the productivity of both crops/vegetables and fish at the same time, reducing its service costs, and contributing to improving the properties of the soil for fish.

Aquaculture in rice fields produces approximately 3,315 tons of tilapia and 2,210 tons of catfish.

### 5.3 Husbandry practices

Starting from the end of February, hatcheries produce fry for the farm to start the farming season in April. Before starting the season, farmers dry the pond and remove any organic matter from the last season (Fig. 22). After that, the pond is disinfected by using quicklime 250-500 kg/acre together with the pond infrastructure and irrigation and drainage channels. Fertilization is also very important in this stage to raise the natural organisms that will be used as natural food by farmed fish. Fry is transported from the hatchery to the farm in plastic bags with a carrying capacity of 1000 fry per bag or in containers with an injection of oxygen followed by acclimatization to on-farm condition. Feeding in fish farms starts from the second day after the fry arrive with suitable feed type, size, and amount depending on fry size and age. In July and August, the temperature rises, and to avoid the high temperature effect, some farmers stop feeding while others increase water exchange. At the end of November and beginning of December, farmers start the harvesting season with an average fish size of 250 g and an average production of 8 tons per hectare.



Figure 22. Drying fishpond in the beginning of the farming season.

#### Fertilization

Most semi-intensive fish farmers in Egypt follow a fertilization program using either a organic or inorganic fertilizer for 8 weeks with 100 to 300 Kg/acre for organic fertilizers, and they calculate the amount of inorganic fertilizers according to water needs. Artificial fish feed is added since the week 7. Farmers are using the Secchi disc to monitor algal density, which should be between 15 and 25 cm.

#### Feeds inputs

Egypt has many fish feed factories, which annually produce about 2.4 million tons with an FCR of about 1.5 depending on feed quality and farm management (Fig. 23). Fish feed in Egypt is extruded and specialized for different fish age groups and purpose of production (Fig. 24). The 27-33% CP (crude protein) for adult fish, 36% CP for broodstock, and 40% CP for fish fry is usually used with different diameters. Also feed for freshwater fish and marine fish with different crude protein percentages, floating and/or sinking feed, in addition to specialized feed for crustaceans such as shrimp. In the last 2 years only, fish feed prices increased more than 200%, due to the high prices of raw materials, as most feed raw materials are imported from abroad.



Figure 23. Commercial feed available in Egypt (Aller aqua, Skrettings, Grand)



Figure 24. Fry feed from age 1-21 days, 22-42 days, 43-60 days and 60-71 days.

### Water condition monitoring in fish farms

Governmental, research institutions and feed companies provide free technical support to fish farmers by monitoring fish health and water conditions like dissolved oxygen, pH, water temperature, ammonia, etc. This is for the purpose of monitoring the condition of farms and predicting potential problems or providing solutions to existing problems.

### Fish seed inputs

Egypt has more than 900 hatcheries for Nile tilapia, with an average production of 157.748 million monosex all-male tilapia fry for hatcheries owned by the government and private sector.

## 6. Namibia

### 6.1 Introduction

The development of aquaculture in Namibia is high on the agenda both in the Government's Vision 2030 and the National Development Plan (NDP5) priority list (NPC, 2017). The development of aquaculture in Namibia is favorable due to several factors that include, amongst others, the vast unpopulated coastline, abundant natural resources such as a large pool of potential aquaculture species, unpolluted freshwater water and political support.

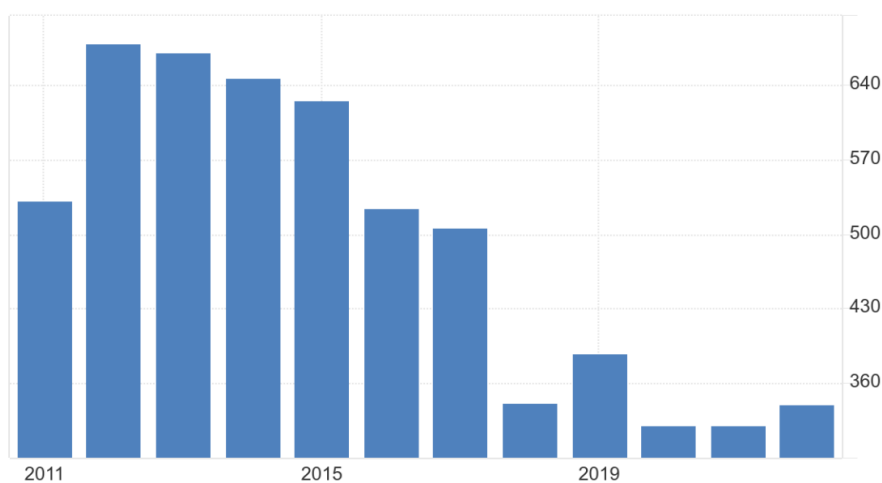
The Namibian government embarked on an aquaculture development drive in early 2000, spearheaded by the Ministry of Trade and Industry, that led the construction of a number of community fish farms in the Oshana, Okavango and Zambezi regions. When the Directorate of Aquaculture of the Ministry of Fisheries and Marine Resources, was established, it took over the mandate and task of developing the aquaculture sector.

The private sector has been slow, if not very reluctant, in coming on board the development of the freshwater aquaculture sector and remains solely involved with mariculture that involves the culture of high value species. The freshwater aquaculture has been portrayed as an area concerned with ensuring food security, low level employment creation and income generation.

There is, however, a need for a wide stakeholder involvement (private, community, higher education institution) in the development of aquaculture as there is a promising indication of this sector being a profitable, prominent food producing activity comparable with other forms of crop and livestock farming.

Aquaculture production (metric tons) in Namibia was reported at 340 metric tons in 2022, according to the World Bank collection of development indicators, compiled from officially recognized sources. Namibia Aquaculture production (metric tons) actual values, historical data, forecasts and projections were sourced from the World Bank in August of 2024 (Fig. 25). This production is mainly based on mariculture (e.g. oysters, crayfish and abalone).

Namibia Aquaculture production (metric tons) - metric tons



Source: tradingeconomics.com | World Bank

Figure 25. Aquaculture production in Namibia over the years.

## 6.2 Aquaculture production systems in Namibia

Aquaculture in Namibia is currently a mixture of extensive and semi-intensive culture systems both in fresh and marine waters. Freshwater aquaculture in Namibia is primarily a government funded initiative, which is community based, being a cooperative activity that requires a high degree of labour and relies on extensive culture methods. The main focus is on food security, income generation and improvement of rural livelihoods with the production aimed at the local and regional markets. Freshwater aquaculture production is very low. Data available indicate that in 2007 only 5 tonnes of tilapia and 11 tonnes of catfish was produced (MFMR, 2007). Species being farmed are the indigenous Three-spotted bream (*O. andersonii*), Red-breast tilapia (*C. rendali*), African catfish (*C. gariepinus*), the exotic Mozambique bream (*O. mossambicus*), and Nile tilapia hybrid (*O. niloticus*). The culture systems employed are ponds, partial recirculating aquaculture systems (RAS) and cages.

In contrast, marine aquaculture in Namibia is characterized by extensive and semi-intensive culture systems, most requiring significant start-up capital and technical expertise. This is due to the fact that some aquaculture facilities are pump-ashore systems, while others are in the few available bays, and this requires boats to reach the long-lines and drum-suspended baskets. Only private investors are involved in marine aquaculture and only high value species are considered. At present the species being farmed are the non-native oysters (*Grassostrea gigas* and *Ostrea edulis*) and abalone (*Haliotis midae*), and a seaweed (*Gracilaria verrucosa*). There are clear signs that marine aquaculture is destined to grow at a fast rate (MFMR, 2009), given the number of applications for aquaculture licenses. For this sector's growth to be sustainable it needs to be founded on well-researched methods of farming and carefully planned business strategies. The challenge for mariculture in Namibia is the annual occurrences of toxic algal blooms and sulphur eruptions. However, marine finfish culture is attracting new interests and there are a few indigenous species that show good potential for culture. At the moment marine aquaculture is mainly confined to the coastal and harbour towns where infrastructure, labour and other amenities are well established.

The Aquaculture Master Plan (2012) advocates that the development of the aquaculture sector should be moving towards diversification, which can be viewed positively as a means to ease the pressure and reliance on wild capture fisheries (both marine and freshwater). Diversification to support stable industrial development is not a radical idea and has been a component of successful aquaculture development in many countries (Corbin and Young, 1997).

## 6.3 Husbandry practices

The most common fish husbandry practices in Namibia are both extensive and semi-extensive cultures. Freshwater culturing mostly takes place in ponds and tanks around the country where there is availability of freshwater. As for mariculture, the organisms are cultured in salt-water using a mixture of extensive and intensive culture in lagoons and bays, and in shore-based tanks. Cage culture is yet to be introduced in Namibia, and at least three companies have applied for environmental clearance to start culturing finfish.

Fish feed is one of the major components needed and most expensive commodities when raising fish. Importing fish feed at a high cost from South Africa has been hindering freshwater aquaculture production



in Namibia. It was through a cooperative agreement between the Namibian and Spanish Government, that a fish feed factory at Onavivi Inland Aquaculture Centre (OIAC) in Namibia was constructed.

The production of Namibia 's own fish feed helps in alleviating the shortage of fish feed, thereby improving fish farming amongst the rural communities, hence improving food security. Activities undertaken at the fish feed plant include fish feed formulation and research (Fish feed trails/experiments). From experiments, it was concluded that a diet of 15% protein is suitable for the use in low scale Semi-intensive farming systems regularly use a low stocking density between 2 to 3 fish m<sup>-2</sup> and a diet of 25% CP, whereas in well managed semi-intensive culture systems, a high stocking densities of 4 to 10 fish m<sup>-2</sup> and a diet of 30% CP is used for broodstock (breeders) and nursing of the fingerlings, while a diet 38% CP is used for the fry stage (Table 1).

Table 1. Estimated Annual quantity of each Diet, for all regions (August 2009 to August 2010) (source: www.mfmr.gov.na).

Diet type	Protein content of the diet	Culture system, fish type and size
Prestarter	38%	Intensive for newly hatched fries
Breeder/Fingerlings	30%	Intensive for fingerlings and broodstock fish
Semi-Intensive II	25%	High scale management for growers
Semi-intensive I	15%	Low scale management for growers

The broodstock of farmed fish in Namibia are always caught from wild stocks emanating from different places or river systems. These are raised at Aquaculture research centers in the Country, until they start spawning, and eggs are collected and hatched in the same systems. The fingerlings are then provided to farmers at very cheap prices in order to promote aquaculture development in the country. The Ministry of Fisheries and Marine Resources are the biggest suppliers of fingerlings in the country, although some private farmers are doing as well.

## 7. Uganda

### 7.1 Introduction

Fish is an integral part of the diet for many Ugandans, contributing significantly to their daily intake of protein and essential micronutrients. However, despite the increasing production levels in the country's aquaculture sector, per capita fish consumption in Uganda remains relatively low compared to global averages. Recent estimates show that the per capita fish consumption in Uganda is approximately 10.5 kilograms per year, which is below the global average of around 20.5 kilograms per year (FAO, 2024)

Several factors contribute to the lower fish consumption rate in Uganda. The country's population has been growing rapidly, and fish production, while increasing, has struggled to keep pace. Economic factors also play a significant role, as fish, although locally produced, can be expensive for many Ugandan households, especially when compared to other protein sources such as beans or pulses. This economic barrier limits access to fish for a large proportion of the population (Mwanja, 2015).

Moreover, the high demand for Ugandan fish in international markets exacerbates the issue. As fish products are increasingly exported, the quantity available for local consumption diminishes, driving up prices domestically. This trend is particularly concerning given the nutritional importance of fish, especially in regions where it constitutes a major part of the diet (Adeleke et al., 2020b).

The Food and Agriculture Organization's SOFIA 2024 report stresses the need for sustainable aquaculture practices to increase fish production in a way that supports local food security. By adopting environmentally sustainable methods, Uganda can improve its fish yields without compromising the ecosystems that are vital to long-term aquaculture success (FAO, 2024).

With its abundant freshwater resources, Uganda holds significant potential for aquaculture development, making it a key component of the national agricultural agenda. Uganda aims at producing 1,000,000 t of farmed fish by 2030 (MAAIF, 2018).

The global rise in aquaculture is a positive indicator for Uganda's potential to increase its output, particularly as the demand for fish continues to grow both locally and internationally (SOFIA 2024). Uganda's freshwater resources include the major Lakes Victoria, Kyoga, Albert, Edward and George, and several rivers that provide an ideal environment for aquaculture. The country's freshwater aquaculture production predominantly focuses on tilapia and catfish, which are well-suited to the local environmental conditions. In recent years, Uganda has seen a steady increase in aquaculture production, driven by both small-scale and commercial fish farms. A study conducted in Mukono, Jinja, and Buikwe districts found that the average farm size is approximately 4,000 m<sup>2</sup>, with the pond sizes averaging 481 m<sup>2</sup>, reflecting growth in farm sizes and indicating a trend towards more intensive aquaculture practices in these regions. It should also be noted that most aquaculture is concentrated in these three districts (Fig. 26).



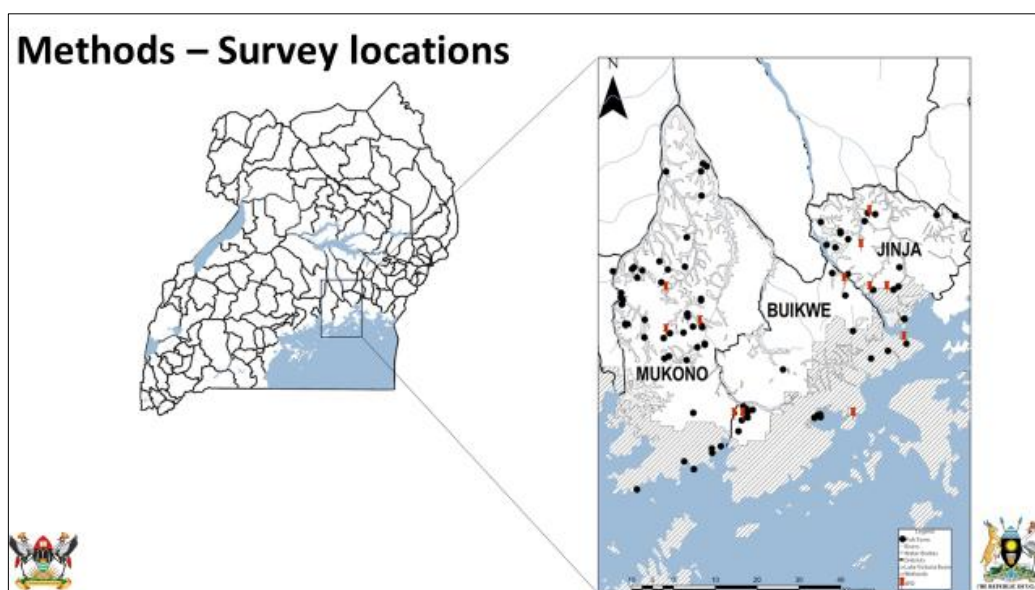


Figure 26. Distribution of major fish farms in Mukono, Jinja and Buikwe districts by 2017 (Map: Semyalo et al., in press).

## 7.2 Aquaculture production systems in Uganda

Aquaculture production is mainly practiced in the Lake Victoria basin and the surrounding water bodies in the districts of Buikwe, Jinja and Mukono. A survey on fish Farming practices in Buikwe, Mukono, and Jinja districts revealed a predominance of semi-intensive farming practices within the Lake Victoria Basin (Semyalo et al., in press), which may also reflect the situation across Uganda. Jinja district had the smallest pond fish farms due to higher incidence of Cage farming (mostly low-volume high-density cages). Overall, the findings reveal that earthen ponds are the primary fish farming systems, followed by fish cages and lined/concrete ponds. Semi-intensive fish farming (where pond fertilization is supplemented with feeding) was predominant (i.e., 63.6%), while a small proportion (i.e., 4.2%) practiced extensive farming (relying solely on pond fertilization). The 32.2% of the farmers (mostly cage fish farmers), completely relied on fed aquaculture. Monoculture (82.2%) was the most common farming practice, particularly focusing on tilapia (96.1%). Cage farms were not included in farm size calculation but are indicative of the overall growth in farm sizes from a national average of 222 m<sup>2</sup> in 2004 (Rutaisire, 2007) to a 10-fold increase to date. The 10-fold increase in farm area is associated with a rise in fish production from 15,000 t to 118,000 t between 2005 and 2015 (Adekele et al., 2020). The drive to increase fish production is associated with growing demand for fish and fish products against increasing decline in capture fisheries, favourable aquatic resources and increased funding to the sector (Kasozi et al., 2017). Despite the observable growth in fish farming over the years, the survey in Buikwe, Jinja and Mukono revealed a high rate of inactive farmers, more so those practicing pond aquaculture, and indicating that the sector is faced with several challenges. Moreover, the majority of active pond fish farmers practiced semi-intensive fish farming that allows them to rely on fertilization and only partly on manufactured feeds. Indeed, the present findings are supported by earlier findings by Edwards (1990), who reported most pond fish farmers surviving by complementing in-situ feed production through pond fertilization. In Uganda, different aquaculture production systems are used, at varying intensity and scale. These systems include:

### 7.3.1 Extensive fish farming

Extensive fish farming, where fish are stocked at low-density and maintained with minimal supplementary feeding, relying heavily on natural food resulting from fertilization is common among small-scale farmers, who practice aquaculture as a sideline activity, in addition to crop or animal farming. Extensive fish farming is common in rural areas where resources are limited (Mugisha et al., 2022). Extensive fish farming in Uganda is typically practiced in ponds or natural water bodies with minimal human intervention. This system relies on natural food sources available in the water and is characterized by low stocking densities. While extensive farming has lower input costs, it also yields lower fish production compared to more intensive systems. On Lake Victoria in Uganda, it is mainly practiced in Jinja Masese, where farmers have formed cooperatives to practice extensive cage fish farming.

Typically, an extensive farming system is characterized by no professional engagement right from farm setting and management, because the farmers are unwilling to incur costs related to feeding and technical engagement; and this was evident among the traditional pond fish farmers and those practicing communal cage fish farming at Masese.

While extensive systems are less capital-intensive, they face issues such as poor control over fish growth and high vulnerability to environmental changes (Kagwa et al., 2023). Recent developments suggest efforts to improve management practices and integrate better stock management to enhance productivity (Kakooza et al., 2024).

### 7.3.2 Semi-Intensive fish farming

Semi-intensive fish farming is characterized by moderate stocking densities and a combination of natural and supplementary feeding. This method is prevalent in Uganda due to its balance between management and feeding costs and productivity. About 63.6% of farms in Mukono, Jinja, and Buikwe employ semi-intensive practices, indicating its widespread adoption (Semyalo et al., in press); and this is indicative of the situation across the country. This approach allows for efficient feed utilization through pond fertilization, but it also raises concerns about nutrient management and potential water pollution, as observed with the high incidence of organic matter in ponds (Kubiriza et al., 2024). Similar to the survey findings in the main aquaculture districts in Uganda, semi-intensive systems are popular among small- and medium-scale fish farmers because they offer a manageable level of investment and maintenance (Bbaale et al., 2022). However, challenges such as water quality management and disease outbreaks tend to persist, and affect their overall productivity (Namulawa et al., 2024).





Figure 27. Fishpond at the Aquaculture Research and Development Centre, Kajjansi – Uganda

### 7.3.3 Intensive fish farming

Intensive fish farming, though less widespread in Uganda, involves high levels of input, including formulated feeds, aeration, and regular water quality management. This system is used in more commercial operations and offers higher yields per unit area. This method aims to maximize production in a controlled environment. Recent studies indicate that intensive aquaculture in Uganda is gaining traction due to its high productivity and the ability to meet the growing demand for fish in urban areas (Ochieng et al., 2022). Key challenges include the high cost of feed, disease management, and the need for skilled labor (Nkuwala et al., 2023). The 32.2% cage operator practices intensive fish farming, where cages are stocked at high density and entirely depending on complete feeds. About 80% of the feeds used in cage aquaculture are imported, and these are less accessible to small-scale and medium-scale fish farmers, more to those dealing with pond fish farming. As a result, most pond fish farmers rely on backyard feeds that are usually of inconsistent quality (Kubiriza et al., 2024). A number of cage fish farms produce fingerlings for stocking grow-out cages. Fingerlings are produced from highly stocked ponds that depend on complete feeds, and usually aerated to maximize survival.

#### Cage Fish Farming

Cage fish farming in Uganda (piloted in 2006) has over the years continued to grow. Several companies and organizations/institutions are establishing new farms not only on Lake Victoria, but also on other water bodies (Kubiriza, 2017). About 1,700 t of Nile tilapia were produced from cages in 2012, and about 3,000 t in 2014. Within the same period, about 27,000 t of farmed fish (both tilapia and catfish) were produced from ponds. Presently, the production of Nile tilapia from cages has increased by almost 10 folds, resulting into substantial volumes of farmed fish being sold on the market. A survey on Africa's great lakes affirmed that 263 installations with more than 20,000 cages had been established on 18 Africa's inland waters by 2019. Of the 263 cage installations, 82.9% were within eight countries, on lakes Victoria, Kariba, Volta and River Volta. Among the eight countries where cage aquaculture is booming, Ghana had 36.1% of the installations,

Uganda 17.9%, Kenya 16.4% and Tanzania 13.3%. The rate at which cage aquaculture (Fig. 28) is expanding in Uganda and in the East African region in general is envisaged to close the fish supply deficit in the region; and equally support social-economic benefits such as increasing auxiliary jobs, provision of employment and increasing household incomes. Recent developments on the Ugandan and Kenyan side of Lake Victoria reveal establishment of farms with large volume: Low-density cages, which productivity is quite high.



Figure 28. A farmer prepares to feed fish at a cage farm near Masese landing site on Uganda's Lake Victoria. He learned cage fishing from his older sister, who runs a successful farm herself. Picture taken by Patricia Lindrio, GPJ Uganda.

## 7.3 Husbandry practices

### Fish Seed Inputs and Management in Uganda

Globally, the use of high-quality seeds and proper hatchery management practices are essential to sustaining the growth of the aquaculture sector. Accordingly, availability and quality of fish seed are critical factors for the success of aquaculture in Uganda. Fish seed inputs include fry and fingerlings, which are produced in hatcheries across the country. Demand for quality and ample fish seed is increasing, yet the country has a limited number of fish hatchery operators. A few hatcheries, and challenges faced, such as inconsistent quality and limited access to high-quality seeds have been noted.

In a study about hatchery practices in Uganda (Mwanja, 2015), there were about 35 operational hatcheries at the time of survey, with over 50% being concentrated in East and Central Uganda, eleven in central Uganda and eight in Eastern Uganda. There were three commercial hatcheries (large-scale) in the country, two of which were located in central region, while one was found in the East, producing between 500,000 and one million catfish seeds annually. Nevertheless, among the most common sources of high-quality Tilapia fish seed include Kagimu Agro Fish Farm (KAMOS), Rock Springs Fish Farm, Yalelo fish farm Ltd, and Aquaculture Research and Development Centre - Kajjansi (ARDC).

## Fish Feed Inputs and Management in Uganda

Fish feed is a critical component of aquaculture, directly influencing the growth, health, and overall productivity of fish. In Uganda, the fish feed sector has seen significant developments, though it still faces various challenges that impact the sustainability and efficiency of fish farming practices. Uganda's aquaculture sector primarily relies on commercial feeds, on-farm formulated feeds, and locally available feed ingredients, with ongoing efforts to enhance feed quality and reduce production costs (Kubiriza et al., 2024; Hadas et al., 2024).

### Types of Fish Feed and Their Utilization

In Uganda, commercial feeds are widely used, particularly in intensive and semi-intensive aquaculture systems. These feeds, often imported, are formulated to meet the specific nutritional needs of fish, including essential proteins, lipids, vitamins, and minerals (Kubiriza et al., 2017; Kubiriza et al., 2024). However, the high cost of these feeds remains a significant challenge, especially for small-scale farmers who often resort to cheaper, on-farm formulated feeds made from locally available ingredients like maize bran, rice bran, and fishmeal (Kubiriza, 2017). Research in fish nutrition and feed management, points to the need for optimizing fish feed formulations to improve feed conversion ratios (FCR) and reduce environmental impacts. The research emphasizes the importance of using high-quality and balanced feeds to maximize growth rates while minimizing waste, which can contribute to water pollution and increase the biochemical oxygen demand (BOD) in aquaculture systems.

### Challenges in Fish Feed Management

The cost of feed inputs constitutes about 60-70% of the total operational costs in aquaculture, making it a major limiting factor for many farmers (Mwanja, 2015). This high cost often forces farmers to use suboptimal feeding practices, such as reducing feeding frequencies or relying on low-quality feeds, which can lead to poor growth performance and increased susceptibility to diseases (Kubiriza et al., 2017). Furthermore, the reliance on farm formulated feeds can result in nutritional imbalances, as these feeds may lack the necessary nutrients required for optimal fish growth.

Environmental concerns related to fish feed management are also significant. Poor feed management practices, such as overfeeding or the use of low-quality feeds, can lead to the accumulation of uneaten feed and fish waste, contributing to water pollution and the degradation of aquatic ecosystems (Tumwesigye et al., 2022). There is a need for improved feed management strategies, including the adoption of better feeding practices and the development of cost-effective and nutritionally balanced feed formulations that minimize environmental impacts (Kubiriza et al., 2021).

To address these challenges, research institutions and feed manufacturers in Uganda are working on developing more sustainable and affordable feed options such as insect-based proteins and plant-based feed additives, which could reduce feed costs while maintaining nutritional quality. There is also a growing emphasis on training and capacity-building initiatives aimed at educating fish farmers on the best practices in feed management. These initiatives include workshops and extension services that provide farmers with the knowledge and tools needed to optimize feed use, improve FCRs, and reduce the environmental footprint of their farming operations (Mwanja, 2015).

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