Development of Aquaculture in Ghana

Analysis of the fish value chain and potential business cases

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Management summary

The main aim of this study was to assess the feasibility of the formation and set-up of one or more Public Private Partnerships (PPPs) for aquaculture in Ghana. The project consisted of two phases. The first phase was a value chain analysis (VCA) of aquaculture in Ghana to identify bottlenecks and business opportunities. The second phase was to develop business cases for investments in aquaculture in Ghana.

Since the demand for Tilapia in Ghana is very high, the focus of this study is mainly on Tilapia. However, other fish species such as Africa catfish are also addressed. The study was conducted through a desk study and a fieldwork mission in Ghana. Different actors in the value chain in Ghana were interviewed to assess bottlenecks and opportunities in their businesses.

Value chain analysis

The VCA illustrates that there is a major bottleneck in existing hatcheries since they cannot meet the market demand in terms of quantity and quality of fingerlings due to a lack of knowledge and experience, lack of equipment and logistics that are not optimised. Since there is a lack of app. 50 million fingerlings annually there is also an opportunity for a business case on Tilapia hatchery (see below and chapter 8).

A major bottleneck in feed production is that there is only one major local feed manufacture (Raanan), which implies that there is not enough affordable feed of a reasonable quality. Importing companies of aquafeeds include Multifeed, Coppens, Skretting and Cargill. Imported feeds are 30% more expensive compared to local feeds which made Raanan feeds popular in many farms. Based on the calculations in our business case (see below and chapter 8), there is an opportunity to produce 30,000 tons per year of additional local feed in Ghana.

Only the local Akosombo strain of Tilapia can legally be cultivated in Ghana. An opportunity for aquaculture development in the country is a more performant strain. Most respondents regard the introduction of the Genetically Improved Farmed Tilapia (GIFT) as an opportunity due to strong indications of about 50% faster growth (specific growth rate) than the Akosombo strain. The introduction of the GIFT strain is not permitted because the environmental risk assessment has not been completed yet. As a consequence the government cannot make a decision about the introduction.

A main bottleneck in the domain of policy is the required procedure for licenses which is described as bureaucratic. More than 5 different governmental agencies are involved in the procedure, which can take up to 1 or 2 years.

Business cases

Based on bottlenecks and opportunities in the value chain, the following three business cases have been developed:

1. Local feed production. To facilitate the growth of Tilapia farming industry and to improve the economic potential of the farms, more feed of reliable quality and economic price is needed. The current capacity of Raanan, the most important feed producer today, does not meet this requirement. There is a market for an additional feed mill with a capacity of 20-30,000 tons of feed annually.
2. Tilapia fingerling production. Presently it is estimated that there is a lack of 50 million fingerlings annually. There is an opportunity for a new hatchery that can produce these quantities of good quality fingerlings, provided that bottlenecks such as a shortage of feed, suitable cage locations and bureaucracy are solved.
3. Farm level training and education in best fish farming practices. The management of some farms is not optimal because of unskilled employees, some farm managers and owners of small- and

medium-scale farms, who do not possess the right knowledge. Because of the lack of data on the shortage in knowledge at the farm level, this business case will be developed further in follow-up projects.

The potentially interested Ghanaian and Dutch partners in these business cases can be found in Annex 3. These three business cases will also be shared with other potential Dutch investors including aquaculture companies, investment funds, and other private sector parties. If companies are interested in any of them a proposal will be developed. Such a proposal will focus on a more detailed in-depth study of the proposed business cases.

1 Introduction

1.1 Background

In Ghana the aquaculture sector has the potential to grow. Since 2000, the fishery sector has been contributing to national GDP with 3-5% only while the agricultural sector's contribution to GDP has averaged 35% (MOFA, 2012). In 2012, the agriculture sector contributed approximately 23% of GDP and is the largest sector employing over 40% of the economically active population. The fisheries sector accounted for nearly 7% of Ghana's agricultural GDP in 2011 and contributed directly and indirectly to the livelihoods of over 2.2 million people in Ghana. Fish is an important food product in Ghana, accounting for 60% of the national dietary animal protein and about 75% of the total domestic fish production is consumed locally. Demand for fish is higher than supply and currently 25% of domestic fish consumption is being imported. The per capita consumption of fish and fishery products is estimated to be about 25 kg per annum and is one of the highest in sub-Saharan Africa.

The government of Ghana has embarked on an ambitious plan to increase the national fish production through aquaculture development. With the support from DFID, NEPAD and the World Bank, the government has elaborated the Ghana Fisheries and Aquaculture Sector Development Plan (2011-2016). Based on this plan, the Ministry of Fisheries and Aquaculture Development with a contribution from FAO regional office has developed the Ghana National Aquaculture Development Plan (GNADP) 2012-2016 (MOFA, 2012). The GNADP aims at increasing the profitability of aquaculture and the production of fish. The aquaculture development plan initially targeted among others an increase in fish production from 10,200 metric tons in 2010 to 100,000 metric tons by the end of 2016, an increase of the market share of commercially farmed fish from 3% in 2010 to 30% in 2016, an increase in the value of farmed fish output from US$ 28,440,000 per annum in 2010 to US$ 362,000,000 per annum in 2016, an enhancement of the effectiveness and efficiency of public sector institutions in aquaculture development, policy making and regulation. With the present figures, this ambitious plan will not be realised in a short term unless identified constraints are quickly removed.

The aquaculture sector is facing challenges. Amongst others, the following factors have been identified as the main constraints to its development:

- Insufficient availability of affordable fish feeds, seed (broodstock) quality and quantity;
- Lack of financial resources for bringing about profitability of aquaculture operations;
- Inadequate involvement of private sector in the development of the aquaculture industry;
- Weak human resource base reflected in the lack of appropriate skills or trained persons at the different levels of the aquaculture sector;
- Lack of effective extension systems for technology transfer;
- Absence of an in-country research agenda that is responsive to the needs of the aquaculture sector.

Since feed costs are approximately 60-70% of the total production costs, the availability of reasonably priced high quality fish feed is one of two key issues for the sustainable development of fish farming. It is expected that, with good farming practices and a second local feed producer, feed costs can be reduced sufficiently. Tilapia production can then continue to grow and aquaculture companies can continue to flourish despite a lower fish price. It is clear that today's practice of feed importation is an expensive solution for the shortage in locally produced, high quality, extruded fish feed. Moreover the locally produced Raanan fish feed is 20-30% cheaper than imported fish feed of similar quality. With affordable local feeds more fish farmers will enter the business and contribute to income generation and job creation in Ghana. At the same time, as a result of the lower fish price, a larger share of the population will be able to afford Tilapia as a food item thus enhancing food security. The second key issue is the

availability of good quality stocking material (fingerlings). In most African countries Tilapia (*Oreochromis niloticus)* is the preferred fish species for farming, market and consumption. Tilapia is indigenous in many parts of Africa, but the achieved growth rates are often not satisfactory. In Ghana recent high mortality rates especially of newly stocked fingerlings in cage farming in Lake Volta have been attributed to poor quality stocking material, transportation and handling. Introduction of better performing Tilapia strains is often not allowed (e.g. in Ghana) because of concerns about escapes and their potential negative effect on genetic biodiversity by interbreeding with wild tilapia. An environmental impact assessment needs first to be completed. Because of this restriction, selective breeding programmes need to be set-up aimed at improvement of local Tilapia strains. Unfortunately, knowledge and facilities for such breeding programmes are lacking in most African countries. In Ghana, the Water Research Institute (WRI) of the Council for Scientific and Industrial Research (CSIR) in partnership with WorldFish, has developed the "Akosombo" Tilapia strain, which is claimed to grow 30% faster than non-improved tilapia according to WorldFish sources. Interest in better performing fish strains, namely the GIFT strain, is very high among most fish farmers and other stakeholders. The strain is already available at CSIR for research and grows faster than the improved Akasombo strain in similar pond conditions (CSIR-WRI, 2013).

The Multi-Annual Strategic Plan 2014-2017 of the Dutch Embassy in Accra supports among other sectors, agriculture, food security and trade. Within the Aid and Trade agenda of the Dutch Foreign Affairs Minister Ploumen, the aim is to facilitate public-private partnerships (PPPs) on sectors such as cacao, palm oil, vegetable and fruit production, and aquaculture. PPPs should be driven by the private sector and therefore also demand driven. For aquaculture the Embassy wants to know what the opportunities are for Dutch business to invest in Ghana and develop the sectors locally. Several Dutch companies are very active in the aquaculture sector in West Africa and in particular in Ghana and Nigeria. They are active along the fisheries and aquaculture value chains. In the fisheries value chain they focus on capture fisheries, distribution and sales of pelagic fish. In the aquaculture value chain they focus on feed production and importation, supply of stocking material and fish farming equipment, consultancy services and aquaculture in the region. The combined strength of these companies together with knowledge institutes such as Wageningen UR and governments could make a significant contribution towards a sustainable development of aquaculture in West Africa.

1.2 Problem definition and aims

The Dutch government actively supports private sector involvement in the agro-food sector in Africa in order to enhance food security as well as to stimulate economic development. The Embassy of the Kingdom of the Netherlands (EKN) is interested to support the Dutch businesses in the aquaculture sector in Ghana.

The main aim of this study is to assess the feasibility of the formation and set-up of one or more Public Private Partnerships (PPPs) for aquaculture in Ghana. Since the demand for Tilapia in Ghana is very high, the focus of this study is mainly on Tilapia. However, other fish species such as Africa catfish are also addressed. The project consisted of two phases. The first phase is a value chain analysis (VCA) of aquaculture in Ghana to identify bottlenecks and business opportunities (chapter 7). The second phase is to develop business cases for investments in aquaculture in Ghana (chapter 8).

The value chain analysis includes analyses of:

- Aquaculture and fisheries production chapter 2
- Import and export of fish products chapter 2
- Major trends in fish supply and demand chapter 2
- Fish markets and prices chapter 3

- Suitability for aquaculture development chapter 4
- Availability of aquaculture inputs chapter 5
- Knowledge infrastructure chapter 5
- Institutions, policy and legislation chapter 6
- Potentially interested Ghanaian and Dutch partners annex 3

1.3 Approach

The following steps have been followed for this project study:

- A desk study of the fish value chain in Ghana based on literature review to collect relevant data,
- A use of contracted local consultant to complete missing data,
- A formulation and discussion of three potential business cases with 2 first interested Dutch companies to ensure that they match the requirements of Dutch private sector companies,
- A field mission to validate and update the value chain analysis and the assumptions for the business cases,
- Finalisation of the report and presentation of the three business cases with potentially interested Dutch aquaculture companies, investment funds and other private sector companies.

2 Production and trends in supply and demand of fishery products

2.1 Fisheries production

Fish production in Ghana depends on marine fisheries that contribute to the highest volume (314,867.57 metric tons in 2013), followed by inland fisheries (86,740.75 metric tons in 2013) and aquaculture (32,512.00 metric tons in 2013). 73% of the total production came from marine fisheries, 20% from inland fisheries and 7% from aquaculture. With the exception of the tuna stocks that remained reportedly unaffected, marine capture fisheries production has followed a downward trend since the mid 90's. Between 2000 and 2013, production from marine fisheries has declined 17% according to MOFAD data (Figure 1). This decline was more than 35% between 2000 and 2011 according to FAO data. FAO data are usually available 2 years behind those of the country year and inconsistencies have been noticed between these 2 sources. Some marine fishermen converted into inland fisheries putting pressure on inland waters, mainly on Lake Volta. Inland production declined 8.7% from 95,000 metric tons in 2012 to 86,741 metric tons in 2013 due to overfishing. The highest inland fish production comes from Lake Volta (about 90%). Fish production in Lake Volta increased from 66,470 metric tons in 2009 to 77,875 metric tons in 2010 and 86,772 metric tons in 2011 (Ministry of Food and Agriculture). The production has declined since and is estimated at 82,635 metric tons in 2013 (MOFAD, 2014). Figure 1 shows the production of capture marine and inland fisheries between 2000 and 2013.

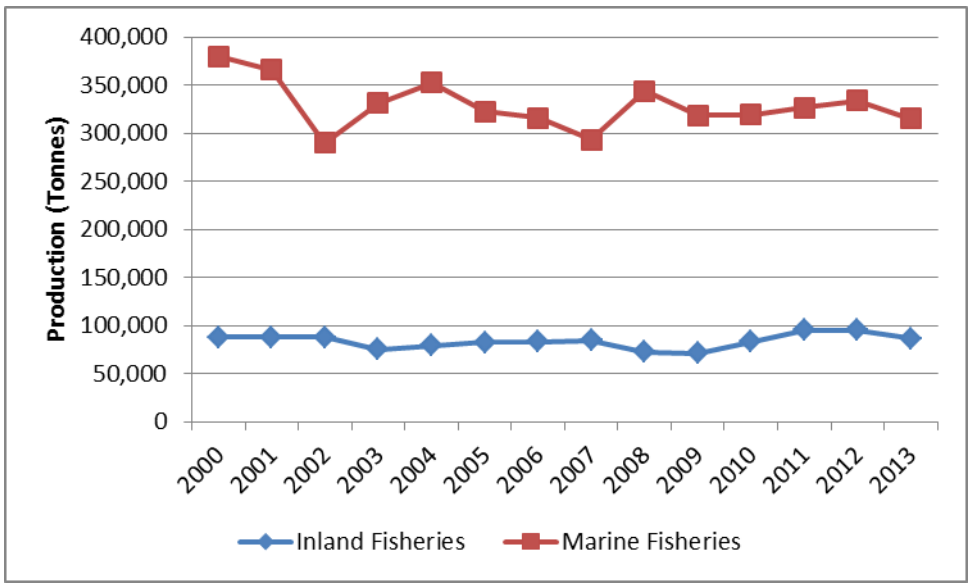

Figure 1. Production of Fisheries production in Ghana between 2000 and 2013.
Source: Ministry of Fisheries and Aquaculture Development (MOFAD).

The marine sector is the most important source of local fish production, delivering more than 70% of the total supply. Marine catch is dominated by pelagic fish: Round Sardinella, Flat Sardinella, Chub Mackerel, Anchovy, Frigate Mackerel, Seabreams, Burrito, Scad Mackerel, Cassava Fish, Tiger Fish, Cuttlefish, Soles, Red Mullet, Hake, Yellowfin, Bigeye, Skipjack, Black Skipjack and other tuna type fishes. In addition, the major demersal fish species are lujanidae (snappers), serranidae (groupers), and polynemidae (threadfins).

The equatorial part of the Gulf of Guinea is the spawning grounds of commercially important Tuna species such as the Yellowfin and Bigeye tuna (Koranteng et al., 2006). The tuna catch is dominated by skipjack or black skipjack though the catch of Bigeye and Yellowfin are significant. Sustainable catch of

tuna is estimated to be 90,000–100,000 metric tons per year, but only 82,899 metric tons were captured in 2013. Pioneer Food Cannery is the biggest Tuna processing company (200 metric tons per day). Both MYROC and GAFCO process around 60 metric tons per day. Figure 2 shows the tuna production and export since 1989.

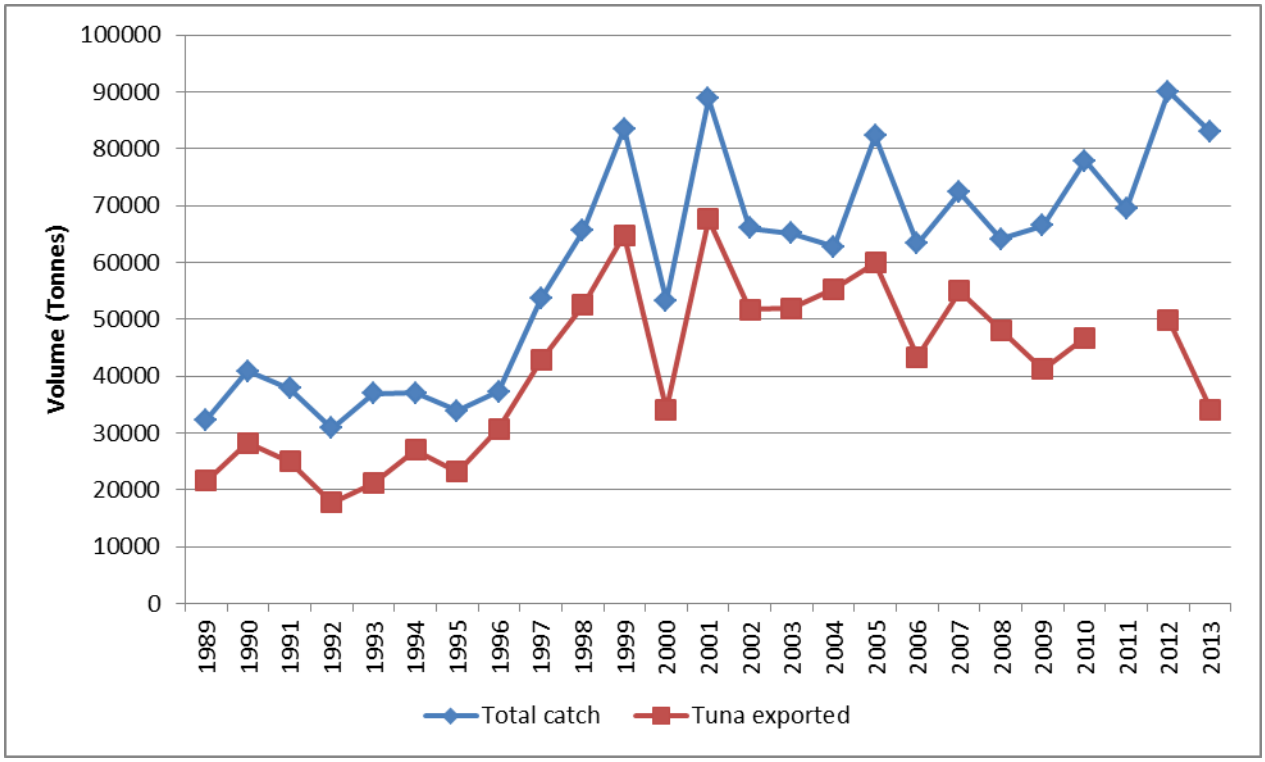

Figure 2. Tuna production between 1989 and 2013 in Ghana.
Source: Fisheries Commission.

Inland fisheries is taking place mainly in Lake Volta which hosts about 143 fish species and provides about 90% of the total inland fish catch. Lake Bosomtwi is a major source of tilapia around the Kumasi area. Other reservoirs behind major dams such as Weija, Barekese, Tano, Vea and Kpong, dams, dug-outs, rivers and lagoons contribute to the rest of inland fishery production. The coastal area consists of plains and numerous lagoons near the estuaries of the rivers. The composition of the commercial catch on Lake Volta (by weight) from 1991-1998 was dominated by *Chrysichthys spp*. (34.4%) followed by Tilapias (28.1%) and *Synodontis spp*. (11.4%), and many few other fish species (Figure 3). Remainders in the figure accounted for less than 1.0% each of the commercial catch by weight (MOFA, 2003 cited by Béné, 2007).

Other non-finfish species from inland fisheries include shrimps (*Penaeus spp*.) and blue crabs (*Callinectes spp*.) from brackish waters (lagoons), and freshwater prawns (*Macrobrachium vollenhovenii*).

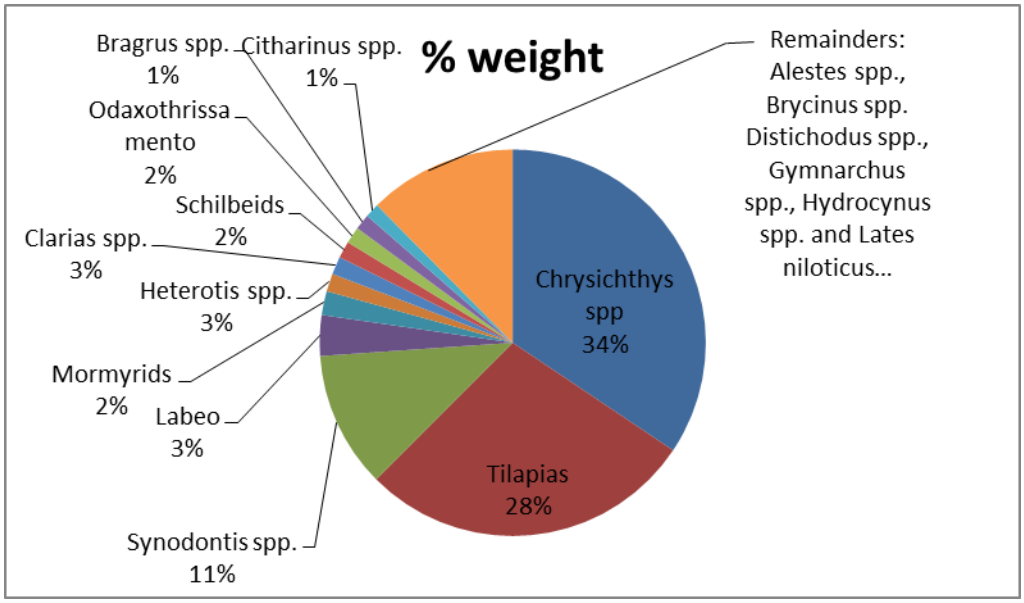

Figure 3. Relative composition of commercial catch by weight between 1991-1998 on Lake Volta. *Source: MOFA (2003) cited by Béné (2007).*

2.2 Aquaculture production

Fish farming in Ghana started in 1953 in the north and is currently practised in all 10 regions (Annex 1), most prominently in the southern and central belts, where small scale and semi-intensive pond aquaculture is dominant and accounts for over 98% of fish farms (Kassam, 2014). The aquaculture sector comprises mainly small scale subsistence producers and few commercial and medium scale producers. Small scale farmers produce various fish species including several species of Tilapia such as *Oreochromis niloticus*, *Tilapia zilli*, *Sarotherodon galilaeus*, *Heterotis niloticus* and catfishes such as *Clarias gariepinus* and *Heterobranchus bidorsalis*. Catfish is mainly important in the Ashanti region where an increasing domestic demand for catfish has been confirmed. The sector is dominated in numbers by very low performing non-commercial systems (extensive, small scale and subsistence) often using earthen ponds, though some high performing commercial initiatives have emerged recently. In the extensive system, dams, dugouts, ponds and small reservoirs are fished out and stocked regularly. In the northern part of the country, an extensive or culture-based fisheries is rather practiced. Non-commercial pond farm types have an average size of 0.36 ha and mean production range from 1,4 metric tons/ha/year to 4.4 metric tons/ha/year. The average production is estimated by the Ministry of Fisheries and Aquaculture Development at 2.5 metric tons/ha/year per pond farm. In 2009 there were about 7 main relatively high performing commercial farmers and 2,869 small scale farmers largely made up of small-scale rural pond aquaculture farms, commonly classified as non-commercial and producing less than 1 ton per annum per farm, in addition to approximately 10 commercial pond aquaculture farms and 76 pens of 6.73 ha (Fisheries Commission, 2009). In 2013, there were 4,749 ponds with a total surface of 704 ha and a production of 2,570.09 metric tons; dugout ponds, dams and reservoirs produced 1,458.69 metric tons in 2013. Pond production accounted for 8% of the total production of farmed fish while dugouts, dams and reservoirs contributed at 4% of the total aquaculture production

Most farmed fish production came from cage farming (88%). The first commercial cage was established in 2001. Aquaculture production increased, mainly due to the production from large–scale cage farms but also the increased availability of quality feeds and fingerlings. The production increased steadily between 2009 and 2014 (Table 1 and Figures 4&5). The increased availability and quality of inputs contributed to

a doubling of cage productivity from 50.5kg/m^3/year in 2009 to 101.7 kg/m^3/year in 2013. Cage farming has developed fast as a commercial activity during the last years with an average annual growth of 73% between 2009 and 2014 (Table 1 and Figure 5). Commercial cage farming consistently contributed to more than 88% of aquaculture production in 2011-2014.

Table 1. Number, volume, fish production and productivity of cages between 2009 and 2013

	Year				
	2009	2010	2011	2012	2013
Number	816	1,148	1,525	2291	2278
Volume (m^3)	97,212	166,500	234,288	279973	279,973
Production (tonnes)	4912	7581	16245	24249	28,483
Productivity (kg/m^3/year)	50.5	45.5	69.3	86.6	101.7

Source: M&E/FC/MOFA (2010); M&E/FC/MOFA (2012); MOFAD (2011); MOFAD (2013); MOFAD (2014). Productivity values were calculated.

These figures exclude the 1200 empty cages recorded in 2013 and reported to the mission. Non-operated cages are found on Lake Volta. Some people mount up cages to secure space for fear of not getting access to space to operate in the near future. There are also cases where some farmers involved in cage production have stopped producing because of the high cost of feed. Most of them were not able to break-even, generally because of the lack of proper management.

During the last decennia, the dominant culture system for tilapia has shifted to intensive cage farming. Tilapia cage farming is done mainly in Lake Volta in small-scale and large-scale cages. The vast majority of cage farms (over 60) are located in Asuogyaman District in Eastern Region, with most small-scale cage farms clustered between Akosombo Dam and Kpong Dam. Clusters of SME cage farms are also developing in areas such as Kpeve in South Dayi District of Volta Region, Sedom in Asuogyaman District and Akrusu in Upper Manya Krobo District of Eastern Region (Kassam, 2014). A strain of *Oreochromis niloticus* known as "Akosombo strain" which was bred-selected by the Water Research Institute's genetic improvement program in collaboration with WorldFish is reported to grow at least 30% faster than the same species in the wild and has been promoted for use in Ghanaian Aquaculture industry. Wild unimproved strains of Tilapia are still being farmed by few farmers. Tilapia is the major species and constitutes over 90% of aquaculture production (Kassam, 2014). The catfishes (*Clarias spp.* and *Heterobranchus spp.)* and *Heterotis niloticus* account for the remaining 10%.

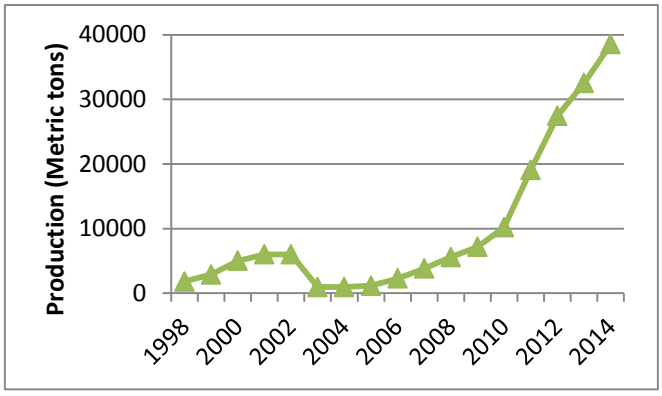

Figure 4. Total annual aquaculture production in Ghana between 1998 and 2014.

Source: Ministry of Fisheries and Aquaculture Development (MOFAD). Provisional data from the Fisheries Commission for year 2014.

Overall, cage farms currently account for less than 2% of farms by number but much more by production. In 2014, estimated aquaculture production from cages was over 33,500 metric tons compared to 3,000 metric tons from ponds and tanks (Figure 5).

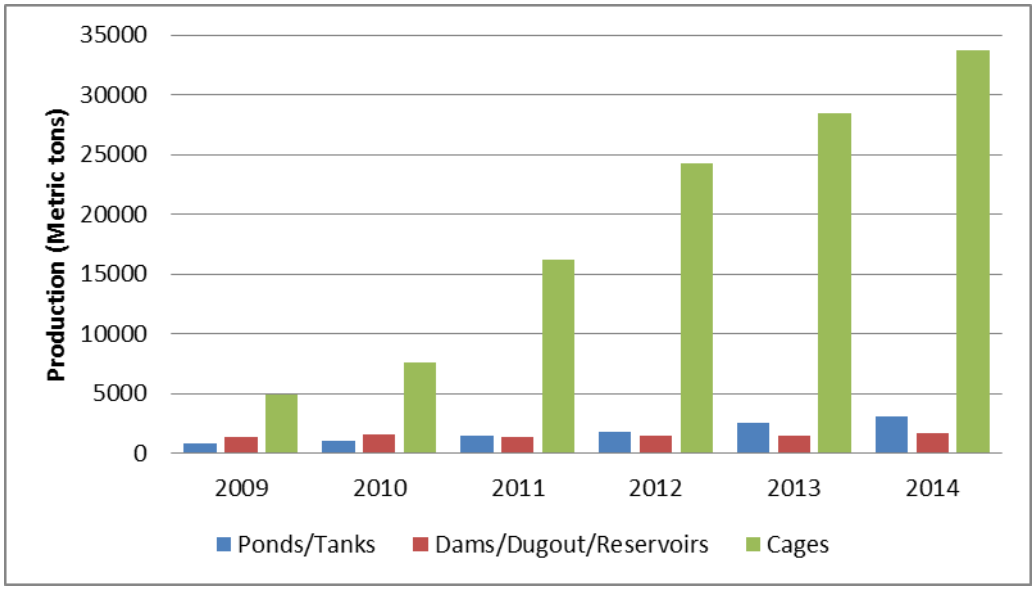

Figure 5. Annual aquaculture production by production systems in Ghana between 2009 and 2014. *Source: Ministry of Fisheries and Aquaculture Development (MOFAD)*. Provisional data from the Fisheries Commission for year 2014.

2.2.1 Main actors in aquaculture production

Functional commercial cage farms in Lake Volta have been estimated and classified by Kaunda et al. (2010) and Kassam (2014) as:

- 2 large scale commercial cage farms, produce over 5,000 metric tons per annum per farm.
- Approximately 10-15 medium scale farms producing 50-1,000 metric tons per annum per farm.
- Approximately 100 small scale cage farms producing 1-50 metric tons per annum per farm.
  Small-scale cage farms consist typically of 1 to 10 cages measuring 5x5x5 meters. According to estimates of the Ministry of Fisheries and Aquaculture Development, such cage produces approximately 10 metric tons per year based on two production cycles per year.

The two large scale commercial fish farms, West African Fish Ltd (WAF) and Tropo Farms, use cage culture, concentrate on tilapia and have fully commercial operations with their own hatcheries and cold chain network (Antwi-Asare and Abbey, 2011). They produce annually 3,000 and 6,000 metric tons of fish, respectively.

Not all farms have sustained their own hatcheries as they still buy fingerlings from other hatcheries to complement their production. Medium scale farmers buy fingerlings from large scale farmers and other sources. They usually depend on the larger farms for their fingerlings and technical advice, although some are provided by the Water Research Institute, Aquaculture Research and Development Centre at Akosombo.

During the field mission in February 2015 the team was able to visit two Tilapia farms in the southern part of Lake Volta. These farms are Sunwoo Culturing Systems and Lee's Farm. A meeting was also organised with Mark Amechi, the CEO of Tropo Farms. However this farm was not visited.

Fish farm information from interviews

Tropo Farms is located in Mpakadan in the Eastern region, 6 km upstream of the Akosombo dam on a deepwater site in the Agina Gorge. Tropo Farms started with a large pond aquaculture farm in Asutuare, Eastern region, near Lake Volta and became operational in 2000. In 2003, Tropo Fams moved into cage farming and started production in 2006 (Kassam, 2014). Tropo Farms employs approximately 700 employees. The output production was 4,000 metric tons of Tilapia in 2013 and 6,600 metric tons in 2014. Projection for 2015 is 5,000 metric tons mostly due to high mortalities of the fingerlings. The target for 2016 is 10,000 metric tons of Tilapia. It is estimated that the Feed Conversation Ratio (FCR) of the Tilapia is 1.7 to 1.9 on average. For large Tilapia FCR is 2.0. Tropo Farms experiences a number of problems. A very high mortality (90%) is recorded from hatched eggs to table size fish. In the first week of stocking fingerlings, already 50% dies. Transportation between the hatchery and the cages seems the main contributor to this high mortality, however the real cause has not been clarified. Tropo Farms attributes the high mortality rate mostly to the usage of the Akasombo strain which is said to be very sensitive to stress and grow slowly. Theft of fish is also a major challenge for the farm that is considering moving his cages 12 km far from the land. At Tropo Farms an estimated 300 tonnes has already been stolen over the years. Therefore the security costs are also very high.

Tropo Farms has a good marketing network supplying several hotels and restaurants. Tropo Farms have cold chain facilities which guarantee the freshness of the fish. Live fish are immediately gutted and rapidly cooled in an ice solution. They are then packed in flaked ice and transported in refrigerated trucks. Fish are then kept in chilled conditions during sales. The fish are never frozen but kept at +1 to +4^{o}C. Harvest-to-table time is kept very short because harvest is on demand, several times a week, 52 weeks a year. Tropo Farms sell Tilapia in several size grades to retailers and wholesalers. Wholesale fish are for 25 kg and above in increments of 25 kg. Fish are sold loose on ice. Tropo Farms has difficulties to sell larger Tilapia (>500 g) and there is a very small demand for fish over 0.6 kg to 1 kg and more. The highest demand in the market is for fish of 250-350 g. Currently the costs of production for the normal sizes are 5-6 GH¢/kg (i.e. 1.5 – 1.8 US$), this includes all other costs such as transportation, security, etc. The selling price of Tilapia is 3.25 US$. Tropo Farms provide also practical on-farm training courses for new and existing fish farmers.

Sunwoo Culturing Systems is owned by Mr. An Dong Bae from Korea. He has over 40 years of experience in aquaculture of shrimp, marine fish, eel and now Tilapia. He invested 700,000 US$ to start his farm of 12,5 hectares (10 ha of water and 2.5 ha of land) in Ghana. He has a permit to use the land and water for 25 years, at a cost of 2,000 US$ per year. His farm currently employs 53 workers. Mr Bae used to produce his own fingerlings but because of economic reasons he is now buying them from other farms at a size of 2 g at a price of 0.05 GH¢ per fingerling. From fingerling to stocking (25 g) size it takes 2 months. The survival rate is high (95%), despite low oxygen levels experienced from time to time.

At Sunwoo fish farm there are 56 cages of 5x5 m stocked with 10,000 fingerlings and 48 cages of 6x6 m stocked with 13,000 fingerlings for the grow-out of Tilapia. From 2 to 25 g, fish are graded 5 times which is the key to the later success of the grow-out phase. Selecting similar sizes for the same cage improves the growth performance and yield. To grow from fingerling size to a 350 gr Tilapia takes 5 months. With a good management the farm achieves a survival rate of 95% during grow-out of Akosombo Tilapia. In

total Sunwoo Farm produces 500 tons of Tilapia per year. Mr Bae uses Raanan feeds and achieves an FCR of 1.5-1.6. The costs of the feed were unknown at the time of the interview but a Raanan feed price list was provided (Annex 2). Sunwoo farm buys Raanan feeds because they are cheaper than imported feeds. Imports become especially more expensive due to the devaluation of the GH¢. Customers come directly to the farm, often buying one or two cages with Tilapia. These distributors come from Accra, Tema and Akosombo and account for app. 80% of all fish sold.

Mr Bae faces a number of problems. Low levels of dissolved oxygen is the main problem during specific months of the year, e.g. during the harmattan season in January-February. This lasts from 7 to 40 days. Another period of low oxygen levels is in July, August and September when the second rainy season takes place. Over the last years oxygen levels have dropped in the southern part of Lake Volta. The lowest oxygen levels measured at Sunwoo farm are 0.4 mg/L inside the cages and 0.6 mg/L outside the cages. In the past high oxygen levels have been measured, from 7.8 to 8.6 mg/L. As a main strategy to cope with a lack of oxygen Mr Bae stops feeding. Reasons for low oxygen levels could be consumption by microalgae growing on organic human waste from land origin, low water levels, and the fact that the farm is located close to the dead end of a side channel of Lake Volta, near the Akosombo Inland Port, and consequently a lack of turbulence and water currents. Mr Bae realises that his farm is located on a site that is not suitable. Therefore he is looking to move to a better location. He made a request and received promises from the Volta River Authority (VRA). This agency promised also to develop infrastructures such as road construction, electricity and water pipes but this agreement was never met. Other problems include theft of fish from the cages during night using cast nets. This results sometimes in losses of more than 200 kg. Diseases occur seldom; Mr Bae reports *Trichodina* and *Edwardsiella*. The latter was treated with 25 g of the antibiotic (oxytetracycline) per ton of feed.

Lee's Farm Ltd is owned by Mr Lee Kuo Rong from Taiwan. The farm has 80 cages of 5x5 m. Contrary to Sunwoo Farm, Mr Lee produces his own fry and fingerlings. His broodstock is always mixed; one originates from the local wild stock of the Volta river and one from the genetically improved Akosombo strain. The reason for crossing lines is to have a healthier broodstock. Mr Lee has been working for 4 years and has more than fourth generations of bred Tilapia. In the past he used to incubate the eggs for hatching; however this resulted in a high mortality of 60-70%. The fry are directly collected and stocked in concrete nursery tanks in hapas for 21 days of sex-reversal. After another month when fingerlings weight approximately 5 g grading and counting takes place. Mr Bae experiences also the lack of market for Tilapia above 500 g. The market demands fish sizes of 250-350 g. This size takes approximately 5 months in total to grow. At Lee's farm the fish is being sold directly to the market. Harvesting and packaging takes place at the farm. The total production of the farm is estimated at 200-300 tons per year. The FCR differs from time to time, depending less on water quality (relatively high FCR from October to March with low dissolved oxygen), but more on performances of employees in charge of feeding fish. The best result is 1.48 and the worst result is 1.85. The farm uses Raanan Feed.

The problems that Lee's Farm experiences are the same as those from Mr Bae. This implies low oxygen levels, theft by fishermen and employees, unqualified employees and the bureaucratic process connected to the wish to move to another location. When asking the villagers close to the farm about their opinion of the farm, it became clear that there have been conflicts in the past when the farm established. These conflicts related to the use of the space and the right to pass the farm with canoes. Over the last years the farm and the villagers have come to an agreement, resulting in several jobs creation at the farm on the benefit of the village.

Crystal Lake Fish Limited exists since 2001. The farm was established by a female Ghanain entrepreneur, Patricia Safo, with support from the Danish International Development Agency (Kassam, 2014). It previously focused on table size production but switched to fingerling production 5 years ago

mainly due to economic constraints. Presently, the company is constrained in energy which is the key challenge limiting fingerling production. It is seeking new investors for financial injection of 0.5 million US$, but also essentially technical input/support. The management claim a production capacity of 2 million fingerlings per week. Our impression is that the basic management skills are lacking, resulting in poor performance of the farm.

Fish farm information from internet and reports

Many other fish farms could not be visited during the mission because of the time shortage. Information was collected from different sources including websites.

West African Fish Ltd is a joint venture between Palm Acres Ltd. and Royal Danish Fish Group A/S founded in 2007 and started producing fish in 2008. The cage farm is located near Asikuma in Eastern region, has a production capacity of over 2000 metric tons of fish per year. The grow-out facilities are located in Lake Volta, in square cages measuring 6 meters on each side until the fish reach approximately 50 g. They are then moved to 50 m circular double net cages until the fish reach the 500 g harvest size. All cages are connected to two floating docks, which allows easy feeding, harvest and overall control of the production and security. The company is also responsible and very active in CSIR activities.

Safeway Agro is a subsidiary of Safeway Estates Limited, a registered Ghanaian company authorized to provide services in project development (Rurangwa, 2014). The fish farm is located at Abui on the shores of Lake Volta in the South Dayi District, Volta Region. Two types of cages are used to farm Tilapia. Twenty small cages of 6x6x2.5m made of PVC pipe frames are stocked at a density of 22.000 fingerlings (0.8-1.5 g) and produce 5-6 metric tons per cage after 6 months. Six cages of 7x7x3 m with high density poly-ethylene (HDPE) frames are stocked with tilapia at a density of 35,000 fingerlings per cage. The expected production from these cages is 8-10 metric tons per cage per 6 months. The survival rate is ±75% at harvest. Recently Safeway Agro advertised in local newspaper its increase of fish production from 350 metric tons to 10,000 metric tons annually.

Other small- and medium-scale commercial fish producers include:

Maleka Farms, medium-scale cage farm in Akuse, Eastern region.
Delta Fisheries, hatchery and cage farm, Eastern region
Tokorozawa Enterprises, small scale cage farms in Sedom, Eastern region
Ainoo-Ansah Farms, hatchery in the Central region
Anson Farm, Senchi: cage tilapia demonstration farm
Aqua Farms Ltd operates in crops, livestock, poultry and fish farming near Accra
Aquaprima Ghana Ltd: fish farms on Lake Volta
Gilgal Farms Ltd: tilapia cage farm
Dakuodeve Fish Farms
Kumah Farms Complex (hatchery and pond aquaculture), in Ashanti region

The **Ghavie Aquaculture Company Limited** Pilot Shrimp farming project, a private initiative between Ghana and Vietnam, was announced mid-2014 to start at Ada-Foah in the Greater Accra Region. It is aimed at pioneering and building a shrimp marine culture industry in Ghana that would provide jobs, foreign exchange, and contribute to food security in the country and beyond. The Ghavie project, which has a hatchery, the first in Ghana and Atlantic Coast of Africa, has the capacity to produce 15 million shrimp post larvae per month, create 2,000 jobs for Ghanaians within a period of five years and 50,000 jobs along the value chain (Under Current News, 2014).

Contact details of the main actors in the sector are provided in Annex 3.

2.3 Imports of fish and fishery products

The volume of fish imports valued at US$200 million annually by the World Bank to compensate the fish deficit has decreased during the last years because of reduced availability of foreign exchange. Imported fish decreased from 181,825 metric tons valued at US$159 million in 2012 to 150,701 metric tons valued at US$135 million in 2013. These volumes are far below the annual deficit estimated at 534,000 metric tons (MOFAD, 2014). This highlights the potentially important role of aquaculture in meeting domestic fish requirements. Imported fishery products are made of low value frozen fish and comprise horse mackerel (*Trachurus trachurus*), chub mackerel (*Scomber japonicus*) as well as sardinella. Dentex species and (used in the poultry industry) are also imported to a lesser degree (FAO, 2004). Fish imports to Ghana are mainly from Morocco, Mauritania, Namibia, Norway, Spain, The Netherlands, Belgium, Senegal and the Gambia (FAO, 2004; Kassam et al., 2014).

2.4 Exports of fish and fishery products

Higher valued marine fishery products such as shrimp, canned tuna, shark fin, grunts (*Haemulidae*), sea breams (*Sparidae*), cuttlefish (*Sepiidae*), grouper (*Serranidae*) and croakers (*Sciaenidae*) are generally exported (Atta-Mills *et al.,* 2004). Over 60% of tuna catch is exported (Figure 2). In 2013, Ghana exported 34,089 metric tons of Tuna and 22,537 metric tons of other fish and seafood (MOFAD, 2014). In 2013, export earnings from fish and fishery products amounted to nearly US$ 210 million. The export destination is mainly EU countries via Spain and Ivory Coast. The export of Tuna to the European market declined in 2013 due to a ban on export. As of 2015 this ban is still in force. The Fisheries Commission of Ghana is in the process of addressing conditionality given to Ghana by the EU. Various demersal species were also exported to Japan, and some cuttlefish, crabs and lobsters to China (Kassam, 2014).

2.5 Major trends in fish supply and demand

Fish is an important food product in Ghana, with per capita consumption of about 25 kg per annum, accounting for 60% of the national dietary animal protein. Ghana is one of the highest fish consuming country in West Africa. Fish accounts for 22.4 % of household food expenditures and for a long time, fish has remained the preferred and cheapest source of animal protein with about 75 % of total annual production being consumed locally. Tilapia has become one of the most important and highly demanded seafood in the rural and urban centers of Ghana (Ministry of Fisheries, 2007). According to Tropo Farms Ltd, the highest demand of fish occurs between January and March, around 20 metric tons/day.

Fish and seafood account for 16% of total household spending on food (GSS, 2008, source in FVC analysis). A survey of national living standards conducted between 1987 and 1999 showed that the proportion of the average household food budget spent on fish ranged from 13 to 19% in urban areas and 17 to 29% in rural areas (Ghana Statistical Service, 2002). According to a recent fifth round of Ghana Living Standards Survey, the overall food budget share in rural Ghana of fish and seafood, both cash expenditure and home produced, was 27% far higher than the share for bread and cereals (15%) and for meat (7%) (Kassam, 2014). The most preferred sizes by consumers and with potentially good market prices for traders are those with size above 200 g and below 400 g. Fish is the most important source of high quality proteins in terms of food security and nutrition because of its price, relative to the prices of other high quality protein sources such as milk, meat and eggs that are very competitive. It is the only source of protein whose shelf life can be readily enhanced through low cost technologies such as smoking, salting and drying and made accessible in remote markets (Aggrey-Fynn, 2001). It is an important cash and subsistent food commodity.

The total national demand of fish is estimated at over 1 million metric ton annually and Ghana is only 50% fish self-sufficient with a fish deficit of 534,000 metric tons annually. In 2013, total fish production from both marine and inland fisheries and from aquaculture was 434,120 metric tons while total needs were 1,062,194 metric tons. Decreasing imports and exports of fish accounted for 150,701 metric tons and 56,626 metric tons, respectively. With reduction in foreign exchange, fish importation can be partly replaced by fish from aquaculture given that the latter is developed. With declining marine fisheries and inland fisheries under pressure, aquaculture is being promoted to supply the fish shortfall. The demand for fresh tilapia is high and keeps increasing.

3 Fish markets and prices

3.1 Fish marketing

Fish are graded and gutted before selling. Prices vary from farm to farm and are dependent on the season and the distance from the market. Seven size classes (Table 2) are defined but the size ranges may vary from farm to farm. Commercial farms act as both retailers and wholesalers. The wholesale fish are sold for 25 kg and above in increments of 25 kg with fish sold loose on ice. The retail sales are for orders less than 25 kg. Fish are sold in bulks of 25 kg to wholesalers and less to retailers. Sizes 2 to 4 (450 g to >800 g) are sold to special customers, hotels and restaurants while lower size classes are sold for home consumption and other markets. Tropo Farms do not sell at farm gate but at their main depot near Tema Roundabout on the Tema/Jasikan Road and other locations around Accra. Some farms bring their products to the market after telephone orders from retailers and wholesalers.

3.2 Tilapia value chains

Two value chains exist for Tilapia in Ghana, the artisanal value chain and the modern urban-based value chain are presented in Figure 6.

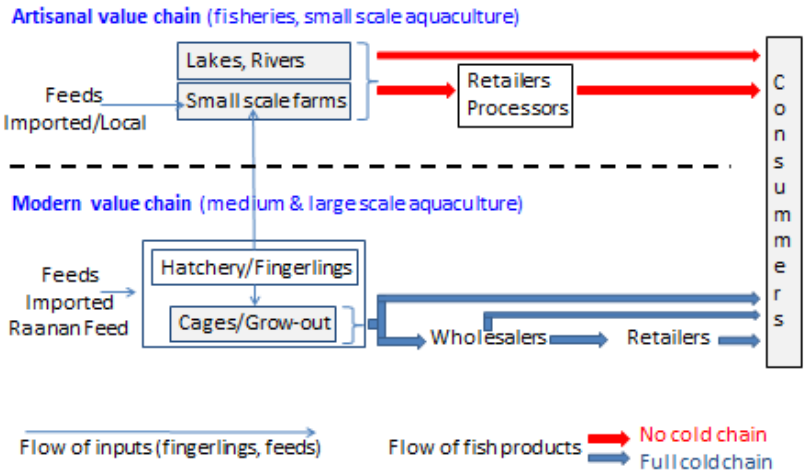

Figure 6. Artisanal and modern Tilapia value chain

Artisanal capture tilapia from lakes, rivers and farmed tilapia from small scale farms are sold to traders and/or processors who in return sell them to the final consumer or sold directly at farm gate. Processed fish products include salted and dried, or smoked tilapia but this only comprises a very small part of total output. The most common form of processed tilapia is the one which is salted and dried; popularly known as "Koobi" in Ghana and around 80% of tilapia, mainly from fisheries, supplied to the market is in this form. The absence of cold storage in the fishing industry makes the distribution of fresh tilapia limited to a few kilometers from the fish landing site. The main problems associated with tilapia salting and drying are hygiene and cleanliness. The salted fish is placed on poly-sheets to dry in the best cases, straw mats, trays, or by the road side in some cases. During the initial stages of drying, flies and other insects are all over the fish. In addition, there are no specific drying sites and control of processed fish for levels of contamination is non-existent. In the case of smoking, it is usually done near the landing sites and transportation cost is minimized (Antwi-Asare and Abbey, 2011).

Tilapia from large scale fish farm are sold whole, alive straight from the farm, and gutted on ice. They are kept in cold chain storage and sold to wholesalers or retailers and these resell in return to

consumers. In some cases producers sell directly to final consumers, hotels and restaurants at the landing sites or farm gate.

3.3 Catfish markets

Processed fish, particularly smoked catfish has a higher demand in inland areas than in coastal areas. In the Ashanti region, the main catfish producer, farmed catfish is mainly smoked although some farmers sell live catfish to buyers in Accra and Kumasi where there is a growing market for live catfish in Nigerian restaurants.

3.4 Fish prices

The prices of farmed fish depends on the species, the size and location of the market. For most small scale pond farms, fish buyers tend to sort, select the fish and negotiate the prices. In large scale commercial farms, fish are graded at harvest and priced by size and sold per kg with prices set by large scale farms. At Sunwoo, 40% of fish have an average individual weight of 500 g, 30% have 350 g, 25% have 250 g and lower. Less than 5% of fish have an average weight over 700 g. Table 2 gives farm gate price range of fresh gutted tilapia. Data were collected in November 2013 in 7 different tilapia cage farms and at Sunwoo Culturing Systems during the field mission (12 February 2015).

Table 2. Farm gate prices of fresh gutted tilapia in different cage farms.

Size class	Size range (g)	Price (GH¢/kg)							
		Survey in 11/2013							02/2015
		Farm 1	Farm 2	Farm 3	Farm 4	Farm 5	Farm 6	Farm 7	Sunwoo
Size 4	>800	N.A.	12.90	N.A.	N.A.	N.A.	8.25	N.A.	9.40
Size 3	600-800	9.60	11.60	8.40	N.A.	9.20	8.25	8.40	
Size 2	450-600	8.80	10.58	7.50	8.00	7.80	8.15	7.50	9.20
Size 1	300-450	8.40	9.96	7.30	7.40	7.60	7.40	7.30	9.10
Regular	200-300	7.80	9.36	7.00	6.90	7.40	7.00	7.00	8.00
Economic	150-200	5.80	N.A.	6.70	5.50	6.60	5.50	6.70	6.60
School boys	100-150	N.A.	N.A.	N.A.	4.80	6.00	N.A.	5.00	

1€=2.96 GH¢ (November 2013); 1 €=4.00 GH¢ (12/02/2015)

The most preferred fish size by consumers is the regular and economy size around 200 g (Asmah, 2008). During the mission, we understood from different stakeholder producers and marketers that the demand market for Tilapia has recently shifted in favour of a size between 250 and 350 g, preferably 4 fish in one kilo. This size category of fish is easily sold out. Bigger fish (over 600 g) have a limited market and their production is not always cost effective. Size 1 and above (over 400 g) are classed as table size and are demanded by hotels. Size 1, economy and regular sizes are demanded by restaurants, tilapia joints and "chop bars". Whereas low income earners and large families are avid fish consumers, it is mostly the relatively small group of high income earners that can afford tilapia at current retail prices.

3.5 Competitiveness of farmed Tilapia in Ghana

Studying the role of the market in the development and performance of aquaculture in Ghana, Hamenoo, Edmond Kwablah (2011) found a lack of competitiveness of Ghanaian farmed tilapia on global markets and with imported frozen tilapia on domestic markets. While a kilogram of fish feed for instance cost US$ 0.30 in Egypt and US$ 0.53 in China, the average price in Ghana is US$ 1.96 (Hamenoo, 2011). The export price of frozen tilapia fillet from China is about US$ 1 while the retail price of frozen whole tilapia in Ghana is about US$ 6.5. The Ghanaian aquaculture is not competitive with low-cost farmed tilapia from China, thus imported tilapia have been prohibited to favour the development of locally produced fish. Even with ban on imports instituted by the Fisheries Commission, imported tilapia from China and Taiwan are sold in cold stores and supermarkets at lower price. Ghana imported close to 2,600 tonnes of tilapia from China in 2013, mostly in whole frozen form. Frozen fillets made up the largest share of imports (45%), followed by whole frozen (33%) and breaded tilapia (22%). The Ministry of Fisheries and Aquaculture Development in Ghana reports that it will do all it can to curtail the fisheries sector threats resulting from tilapia imports to the country (Globefish, 2014).

During the restriction period of import of frozen Tilapia to Nigeria, part of these fish has been found also on the market in Ghana for a short period. Ghanaians generally prefer fresh tilapia to frozen ones (Kassam, 2014), however, there is high propensity to patronize cheaper frozen fish when available.

4 Potential for aquaculture development

4.1 Physical environmental conditions

Akosombo Dam, which was built on the Volta River in 1965, provides hydro-electricity for Ghana and some of its neighbouring countries. The construction of the dam flooded part of the Volta River Basin, and led to the subsequent creation of Lake Volta (Figure 7). The lake has very good water quality and forms the backbone of the entire inland capture fisheries. Over the entire lake there is virtually no polluting industries or dense populations that could possibly cause contamination of the water for tilapia cage farming. Over the years, the presence of a textile industry, Akosombo Textile Limited, located <2 km below the Akosombo dam, a tissue paper production located 5 km below the dam, and presence of banana plantation companies sited along the fertile flood plains of the Volta system (above the dam at Labolabo, and between Akosombo and Kpong dams) have been monitored strictly by the Environmental Protection Agency (EPA) for effluent quality discharges. However, for a long term sustainable management of the lake, the present monitoring system should be intensified. Also, a suitability map for fish farming should include data on the natural fish distribution, water quality data, bathymetric data, presence/absence of roots from dead trees and the different use of the lake (hydro-electricity generation, fisheries, cage farming, tourism, transport, irrigation, potable water production). For this purpose multi-layer interactive GIS maps could be useful. The Ghanaian government has started the zoning of the lake to demarcate the possible areas for cage farming. Anthropogenic activities on the Volta river and lake Basin would also be necessary to document and to predict the future impact of human activities on the sustainable water quality of the lake.

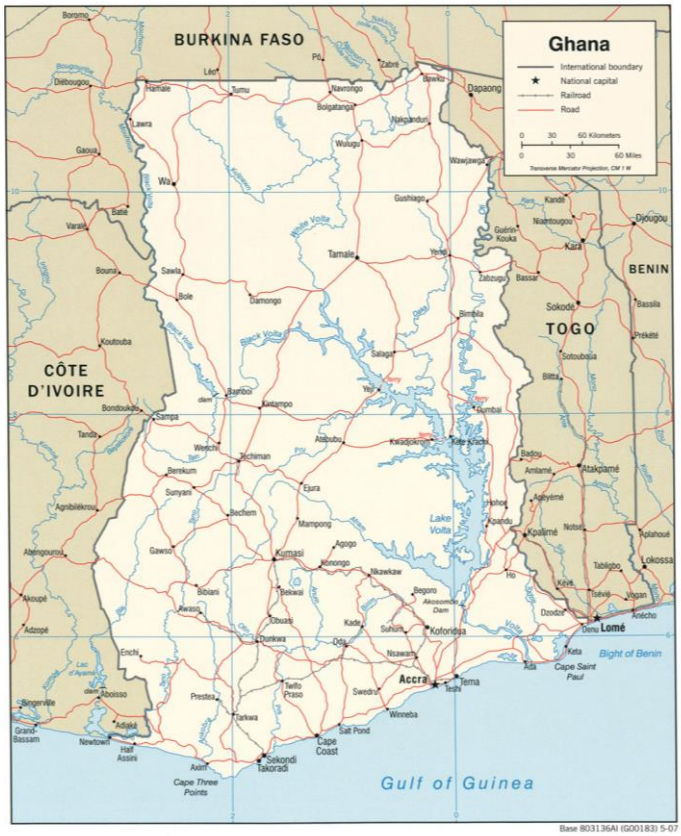

Figure 7. Map of Ghana and Lake Volta

4.2 Economic environment

Ghana's economy has maintained commendable growth trajectory with an average annual growth of about 6.0% over the past six years. In 2013 growth decelerated to 4.4%, considerably lower than the growth of 7.9% achieved in 2012. Growth has, however, been broad-based, driven largely by service-oriented sectors and industry, which on average have been growing at a rate of 9.0% over the five years up to 2013. Over the medium term to 2015, the economy is expected to register robust growth of around 8%, bolstered by improved oil and gas production, increased private-sector investment, improved public infrastructure development and sustained political stability (African Economic Outlook, 2014a).

The continued widening of the budget deficit has been a major constraint to fiscal and debt sustainability. Following an expenditure overrun in 2012, marked by an unprecedented budget deficit of around 12% of GDP, the situation persisted in 2013, with about the same level of budget deficit. Revenue enhancing and expenditure consolidation measures in 2014 could not ease the fiscal deficit to the expected 9%. In conjunction with fiscal constraints, inflation has been on the rise resulting from a number of factors including the removal of subsidies on petroleum prices and a gradual rise in electricity and water tariffs. It is also worth noting the rise in public debt from 43% of GDP in 2011 to 48% in 2012, and further to 53.5% in September 2013, resulting from a widened budget deficit. The external sector may continue to experience a widened current account deficit in 2015, exacerbated by a decline in commodity prices of major export commodities, particularly on gold and cocoa. With the exception of some food processing and significant exports of gold and unprocessed cocoa, Ghana is relatively less integrated into global value chains due to its infant industry. Yet, compared to its regional peers, Ghana has the industrial capabilities to export and drive regional value chains in Economic Community of West African States (ECOWAS) countries. Ghana's geographical proximity to ECOWAS markets, projected rise in consumption and lower standard requirements offer Ghanaian industrial firms opportunities to scale up and increase their productivity. For the industrial sector to grow, authorities need to tackle the constraints relating to the cost of credit and to the unreliable supply of energy, in order for leading industrial sectors in construction materials, textile, agro-processing, plastics and pharmaceuticals to expand. Non-tariff barriers also add a significant burden to the development of these regional value chains (African Economic Outlook, 2014a).

4.3 Political environment

Ghana is considered one of West Africa's most resilient democracies, holding six elections and peaceful transfers of power between the country's two main political parties since 1992. In a turbulent region, Ghana's political stability has been a fundamental asset to foreign investors. Ghana boasts of one of Africa's most dynamic press industries, and improved its ranking in the 2013 Reports without Borders' World Press Freedom Index from 41st in 2012 to 30th position. Although several high-level corruption cases were publicized in 2013, corruption continues to be a significant problem. The peaceful adjudication of the election petition by the High Courts and the fact that both political parties abide by the ruling has further consolidated Ghana's democracy. The December 2012 election was won by the ruling party, the National Democratic Congress (NDC) under the leadership of President John Dramani Mahama, by a narrow margin of less than 1% (325 000 votes out of 11 million). The election results were challenged by the opposition New Patriotic People's Party (NPP), which alleged election irregularities and the cancellation of over 1 million votes. Ghana's Supreme Court, on 29 August 2013, dismissed the case and upheld John Mahama as the legitimate elected President. The court case divided the country not on ethnic, but on political lines. Despite this, the risk of instability was muted by calls from Civil Society, the clergy and the Peace Council for peace to be maintained in the country. The outcome of the

petition has highlighted the need for electoral reforms especially in regards to the appointment and supervision of electoral officers (African Economic Outlook, 2014b).

4.4 Infrastructure

In the past big cage fish farms were established along the Volta Lake in locations without basic infrastructures and had limited accessibility. Roads, hospitals and schools were constructed afterwards sometimes with the contribution of the fish farms. Connections to the electricity grid were done by big farms who could afford the cost. Majority of these big farms are located within the gorge area, covering about 35 km from the Akosombo dam. However, present locations where clusters of small scale cage farmers operate are averagely endowed with road network, national electricity grid and sometimes schools. These farms are dotted near existing fish landing sites (e.g. Kpando Torkor, Dzemeni, Akateng) and/or established towns and villages such as areas around Akosombo, Akwamufie, Sedorm, Atimpoku, Senchi, Akuse (Eastern Region), Kpeve Dorno, Torgome, Sogakope, Sokpoe, Tefle, Vume (Volta Region). Most established towns have adequate hotel and guesthouse facilities of various standards. Among these towns, Akosombo area ranks highest in respect of numbers of hotels/guesthouses and quality of hospitality services.

Road networks and electricity connectivity to potential sites along the Volta Lake for aquaculture remain a major challenge. For Ghana to realize its targeted 100,000 tons aquaculture production by 2016, as anticipated in the Ghana National Aquaculture Development Plan (GNADP), a concerted effort will be required to provide access to sites earmarked for fish production. This will serve as incentive and encourage potential investors to establish farms along the Volta Lake and therefore contribute to increased fish production and stimulate economic growth. The roles of Ministries and their Agencies, *viz;* Roads and Highways, Fisheries and Aquaculture Development, Local Government and District Assemblies, will be critical in the planning, financing and execution of projects directed towards expanding access to aquaculture sites.

5 Availability of aquaculture inputs

5.1 Water resources

The country is drained by a large number of streams and rivers (Figure 7). All major rivers flow into the Gulf of Guinea directly or as tributaries to other major rivers. The most important river is the Volta dammed at Akosombo, Akuse and Bui (situated on the Black Volta) for hydro-electric power generation. The lower Volta is fed from the lake above the Akosombo dam site. The Volta river and its tributaries drain more than two thirds of the country. Other rivers are the Pra, Ankobra and Tano. Among the smaller rivers are the Densu and Ayensu which provide Winneba and parts of the capital, Accra, with pipe borne water.

Lake Volta (Figure 7) is the largest man-made lake in the world by surface area (8,480 km^2) and the world's third largest by volume (app. 150 billion m^3). The lake has a shoreline of 5,200 km and an average depth of 18.8 m. The deepest portions of the lake are about 90 m. The seasonal rise and fall is about 2.0 – 6.0 m and the areas covered by seasonal fluctuations are about 100,000 ha. The largest natural lake in the country is Bosomtwi with a total surface area of 48 km^2 and reaches depths of 72 m in some parts.

The largest water reservoir is Kpong (36.5 km^2), downstream of the Volta Lake (Béné, 2007). Other reservoirs of importance include Vea and Tono in the Upper East Region, Weija and Dawhenya near Accra, and Barakese near Kumasi. About 92% of the reservoirs are 100 ha or less. In addition there are about 90 brackish water lagoons along the coast, with a total surface area of about 400 km^2. The largest is the Keta lagoon situated close to the delta of the Volta River. Other major lagoons include Songaw, Sakumono and Muni. Other water bodies include dugouts and dams (Annex 1).

5.2 Feeds

Feed constitutes the highest production cost (above 60%) in fish farming, especially in cage farming where complete floating feeds are used. Floating feeds are partly imported and produced in Ghana. Raanan Fish Feed is currently the only large commercial feed company that produces extruded fish feeds in Ghana. Small scale fish feed producers: West Africa Limited, AgriCare Ltd, Ghana Agro Food Company Ltd (GAFCO) have been active in the past and produced pelletized feeds. Beacon Hill Fish Feed is still producing fish feeds in Kumasi and markets them mostly in the Asuogyaman District (Akosombo area). The company produces relatively small volumes of press pelletized feeds on demand (1,560 tons annually). The company's feed plant is currently producing at half its capacity of 3,120 tons/year in 2 shifts. Raw materials are sourced from the local market such as part of the fishmeal, corn, palm oil, wheat bran (locally produced from imported wheat) and a proportion of soya bean cake. The majority of soya is imported from Brazil or Argentina. All other ingredients are imported. Imported feeds are diverse on the local market: Skretting and Coppens feeds from The Netherlands, Cargill feeds from Brazil, MultiFeed from Israel. AquaFeed, Aqua Engine and Pira Alevino feeds have been on the market but could not sustain. Nicoluzzi feed (Brazil) is no longer imported. Ahmed (2013) listed other imported feeds on the Ghanaian market from different countries: Inter quality (premium quality) 7002 feed (Singapore), P. T. Matahari Sakti (Indonesia), Inter Quality Premium (Vasafeed Co. Ltd) from Vietnam, Aller Aqua feed (Denmark), Proaqua (Nuton Alimentos Ltd.) from Brazil. Feeds from Egypt and China were cited without further information. Feed distributors for the different feed companies are established around Atimpoku and Akosombo in Eastern region and supply a variety of feeds. The price of fish feeds fluctuates depending on the availability and prices of raw material on international markets. Locally manufactured Raanan feeds are on average 30% cheaper than imported feeds. Most fish out-growers use Raanan feeds.

Raanan Fish Feed West Africa Limited is the only local industrial producer of floating extruded fish feed in Ghana. The feed mill is located approximately 50 km east of Accra in Prampram and employs a total staff of 120 people in 2015, working in 3 shifts 7 days per week. Construction started in 2011 and operations began in 2013. The total investment was 4 million US$ with a working capital of 6 million US$. The company received funding from the Netherlands via the PSI program. The facilities include a milling plant, a laboratory for quality control, offices, storage for raw material and finished products and warehouses. The production process complies with international certification according to ISO9001, ISO14001 (environment) and OHSAS18001 (occupational health and safety) standards. Raanan sells directly to the farms (cages & ponds) and via its distributors (Raanan, 2015).

The raw materials for the Tilapia and Catfish feed are sourced partly locally and partly imported as mentioned above. Animals proteins imports include feather meal, poultry by-products, blood meal, meat and bone meal. These proteins come from Italy mainly and to a lesser extend from The Netherlands. Premixes and amino acids are imported from Israel.

The plant was originally designed for a production of 4 tons per hour; after several upgrades the production reaches nowadays 5.5 to 6 tons per hour, which is the maximum with the current systems. Raanan produces annually 30,000 tons of feed, of which 25,000 tons for the domestic market and 5,000 for the export market. 4,000 tons are exported to Nigeria and 1,000 tons to Mali, Benin, Ivory Coast and Togo. On the domestic market most of the feed is sold to six large farms: West African Fish Ltd Farm (Denmark), Tropo Farms (Nigeria/Germany), Sunwoo (Korea), Maleka (Lebanon), Triton (India) and Lee's Farm (Taiwan). The starter feed of Raanan contain 45% protein and 8% fat. The grower-feed contains 36% protein and 6% fat. The finisher feed contains 32% and 6% protein and fat respectively. In 2015 Raanan is working on building a new warehouse and the establishment of a crumbling line which will enable the production of the starter feeds locally. The latter are presently imported.

The devaluation of the local currency (GH¢) affects the price of imported raw material and thus the feed prices of both Raanan and imported feeds. Over the last years the GH¢ has been devaluated from 1.9 GH¢/US$ to 3.9 GH¢/US$. Imported ingredients are mostly paid with expensive US$; with a GH¢ that is worth less. Last but not least and not surprisingly, Raanan finds the bureaucracy cumbersome. Too many governmental organisations involved do not cooperate.

Import of fish feeds is tax free in Ghana and is operated by the private sector. All imported feeds are floating extruded feeds and pellet sizes range from 0.3 mm to 6 mmm. Powdered/crumbled fry feed are also imported. The biggest active players in import of feeds are: Multifeed, Coppens, Skretting and Cargill. Coppens Intl has a daughter company called "Coppens Ghana" that imports feeds from their factory in the Netherlands. They sell the feed to small and medium sized tilapia growers located along the Volta lake. Coppens Ghana offers technical assistance to the growers. During the mission the team also discussed with a distributor working for Coppens. Coppens feeds are exported from The Netherlands to Ghana and Nigeria. For Ghana this is 100 tonnes per month compared to 1000 tonnes per month to Nigeria. Feed is shipped from Rotterdam to Accra and Lagos, costing app. 2,000 US$ for a container with 25 tonnes. Compared to Raanan feed Coppens feed is more expensive. Coppens starter feed costs 2.81 US$/kg and approximately 2.74 US$/kg for Raanan starter feed. Coppens grow-out feed costs 1.36 US$/kg while Raanan grow-out feed costs 1.01 US$/kg. Coppens feeds generally contain few more protein than Raanan products. Coppens feed contains 45-47% protein for starter feed whereas Raanan starter feed contains 45%. For grow-out feed the protein percentage is 36% for Coppens and 32-33% for Raanan feeds. In practice, farmers therefore feed the broodstock with Coppens feed and the grow-out with Raanan feed. Skretting operates in Ghana through a local agent "Globbas" which deals only in feeds from Skretting. Customers of Globbas are located on the Volta Lake and grow tilapia in cages. Globbas

supplies feed to up to 350 customers varying is size. Large (10% of total) customers are Tropo Farms and Safeway Farms. Tilapia aqua feed imported in Ghana increased from 21.5 tons in 2006 to 518.7 tons in 2009 (Ahmed, 2013).

Beside commercially produced feeds, farm-made feeds and supplemental feeds (agriculture by-products) are being used locally, mainly in pond farming. The formulation of farm-made feeds is mainly depending on the costs of ingredients rather than the nutritional requirement of the fish (Ahmed, 2013). Feeds are pelletized using simple other purpose build electric devices and presented to fish either as wet doughs and moist feeds during the rainy season and as dried feeds during the dry season. Raw material used for farm-made feeds include: bran of wheat, maize, rice, maize meal sweeping, soybean, groundnut peal, palm kernel chaff, pito waste, blood from slaughter house, poultry manure, fish meal and starch as a binder (for ex. cassava starch). Very few farmers use premixes in the feeds. Farm-made feeds are poorly bound and quickly disintegrate in contact with water. They are also poorly digestible.

Small-scale pond farmers practice supplemental feeding additional to pond fertilisation. Common supplemental feed ingredients are wheat bran, maize bran, rice bran and other cereal brans, which are readily available on the market. Other supplementary feeds include agricultural wastes such as cocoyam leaves, agriculture-industrial by-products (local brewery waste and household food waste). A minority of pond farmers use commercial floating feeds.

5.3 Seeds

In Ghana only locally strains, such as the Akosombo strain of the Nile Tilapia *Oreochromis niloticus*, can be cultivated. Other strains are currently forbidden by law. The reason for this regulation is to protect Lake Volta from non-indigenous species (NIS) and potential ecological risks. This entails several problems, of which the main issue is that the Akosombo strain does not grow very fast and has a high mortality. Moreover the strain is reported by farmers to be sensitive to temperature below 25 °C and stress. From a non-official document prepared in October 2014 by Jacques Magnée (Raanan) and Mark Amechi (Tropo Farms) on behalf of the National Aquaculture Association of Ghana on the request of the former Minister of the MOFAD, the authors stated that high mortalities are experienced in all hatcheries when temperature drops 2 or 3^{o}C. Mortality rates of fingerlings from 75 to 95% are often registered after handling, grading, transfer or transportation. Compared to performance recorded in Tilapia farms in many other countries around the world with similar climatic conditions, the growth rate of the local Akosombo strain shows very poor performances. In the trials in Ghana, GIFT show a 50% higher specific growth rate than the Akosombo Tilapias. With a long production cycle to reach the market size, the production costs is high as the local strain is not efficiently converting the already expensive fish feeds. The FCRs were respectively 2.9 and 3.2 for the GIFT and the Akosombo strains during pond grow-out trials with Raanan feeds. The industry is calling decision-makers in Ghana for a solution to prevent bankruptcy in the sector and to expand the business of key players. An alternative would be the Genetically Improved Farmed Tilapia (GIFT). In 2000, Tropo Farms imported GIFT broodstock from Nam Sai Farms in Thailand and started producing fingerlings and 800 g Tilapia. In 2003, the Ghana Environmental Protection Agency discovered that Tropo Farms had been importing GIFT, which was banned and required to destroy all GIFT broodstock, fingerlings and fish (Kassam, 2014).

From 2008-2012 a project Tilapia Volta Project (TIVO) has been conducted to assess the ecological risks of introducing GIFT in Ghana. However the project has not been completed. Therefore the Ministry of Fisheries and Aquaculture Development has not been able to decide if the GIFT would be allowed in Ghana. Furthermore a study of the genetic characterisation of the wild and cultured local strains in Lake Volta and its rivers is finished, but not published yet. The outputs of this study conducted by WorldFish is required for the release of the GIFT strain for farming. The FAO, as coordinating institution, transferred

the management of the TIVO project, as basin-based project, to Volta Basin Authority (VBA). Currently there is no money to continue these efforts. The Fisheries Commission is meeting stakeholders by the end of February 2015 to discuss ways forward for possible agreements, roadmaps and work plans to release the GIFT strain.

In 2012, 60 breeders of the GIFT strain of Nile Tilapia were imported from Malaysia and held in quarantine for experimentation at the Aquaculture Research and Development Center (ARDEC) of CSIR-Water Research Institute (WRI) in Akosombo. The CSIR-WRI has been performing comparative growth experiments in hapas and ponds between the Akosombo strain and the GIFT strain to identify the culture performance differences between the two strains. The preliminary early-life growth results indicate that the GIFT strain grows faster than the Akosombo strain and is more reactive to feeding. The mean seed production per month of the GIFT strain and of the Akosombo strain was not statistically different: 112.48±34.10 and 138.99±33.62, respectively (CSIR-WRI, 2013). The growth trend seems to be same for older life stages.

Fingerlings are one of the major inputs required in setting up any aquaculture enterprise. Over the years its availability and quality has been a major bottleneck to many aquaculture operators. As a result of the rapid growth of cage farming, the number of private hatcheries has increased from 4 hatcheries in 2005 to 16 private hatcheries in 2012 and 24 hatcheries in 2013 (MOFAD, 2014). The number of public hatcheries remained unchanged to three: the Ashaiman Aquaculture Demonstration center in Greater Accra, the Pilot Aquaculture Center (PAC) in Kumasi in Ashanti Region, and the hatchery of the Water Research Institute in Akosombo, Eastern Region.

The highest numbers of fingerlings are produced in hatcheries located in the Greater Accra (39%) and the Eastern (24%) regions to supply cage farms with stocking material and their number keeps growing each year. Out of 27 hatcheries recorded in 2013 (Table 3), 24 hatcheries were producing only tilapia fingerlings. One hatchery was producing both tilapia and catfish fingerlings and 2 hatcheries were producing only catfish fingerlings. Tilapia fingerlings represented more than 99% of the total fingerlings production, the rest was of catfish (<1%) in 2013 (MOFAD, 2014). For catfish, native wild stocks and domesticated farm stocks are largely used, although cross breeds of wild populations are commonly used to maintain vigor. In recent years, catfish broodstock imports from Nigeria have been introduced into some fish farms in Ghana. The total number of tilapia and catfish fingerlings produced in all hatcheries increased 63% from 79,380,269 in 2012 to 130,127,500 in 2013 (Kassam et al., 2014; MOFAD, 2014). Several medium-scale and large scale cage farms produce their own fingerlings and only sell to other farmers when they have surplus. Main private hatcheries supplying fingerlings to cage farmers are Fish Reit (25 million fingerling per year) and Crystal Lake Fish Limited (15-16 million fingerlings per year).

According to Kassam (2014), the prices of Tilapia fingerlings vary depending on size and whether they are sourced from private or public hatcheries, the latter being subsidised and cheaper:

- 2-5 g Tilapia fingerling: 0.10-0.15 cedi
- 10 g Tilapia fingerling: 0.20-0.25 cedi
- 5-10 g Catfish fingerling: 0.40-0.50 cedi

During the field mission, two public hatcheries were visited (Ashaiman Aquaculture Demonstration Centre, Aquaculture Research and Development Centre). Public hatcheries could not be visited and information was collected from interviews (Crystal Lake, Tropo Farms) and reports (Tropo Farms, West African Fish Ltd, Safeway Agro).

The **Ashaiman Aquaculture Demonstration Centre** is located approximately 40 km northeast of Accra. The Centre is a public hatchery, operating under the Fisheries Commission of MOFAD. It focuses

on practical trainings for farmers and the supply of fingerlings. The centre is subsidised by the Ghanaian government, therefore fingerlings are cheaper when compared to private hatcheries. The hatchery focuses for 95% on Tilapia and for 5% on Clarias (catfish) production.

The **Aquaculture Research and Development Centre** (ARDEC) of the CSIR-Water Research Institute is a public center which focuses on research related to aquaculture development in Ghana. It also supports the aquaculture industry in capacity building of farmers, students and fisheries officers, as well as the production and distribution of broodstock and fingerlings using the local Akosombo strain. Annual fingerling production of ARDEC is 7 million per year, mainly for research but distributes 2.5 million per year to growers. It supplies broodstocks of the local strain to major hatcheries including Crystal Lake Fish Limited, the biggest private hatchery in the country. Through a family based selection, CSIR released the 10^{th} generation of Akosombo strain in 2014.

Crystal Lake Fish Limited claims having realized 200,000 fingerlings per week in 2014 (annual production of 10 million fingerlings). Production targets for 2015 are 300,000 fingerlings per week. Fingerlings of 1 g are sold GH¢ 0.10–0.12 per piece, 2 g fingerling is sold GH¢ 0.12–0.15 and 5 g fingerling is sold to Tropo Farms at GH¢ 0.17.

Tropo Farms has a dedicated 32 acre hatchery at Asutsuare on the Volta River near Akuse. Breeders are selected from nature, from the Volta Lake. Tropo Farms controls every stage of production, from eggs through nursery, transfer and final growing in the pure clean river and lake waters of the Volta. Tropo Farms produces its own swim up fry, approximately 7 million per month. Fingerlings are also purchased from Crystal Lake. Over 99% male Tilapia fingerlings, graded and conditioned, packed are cheaper at Tropo Farms than above prices: 0.2 g fingerling for 0.04 cedi, 2.0 g fingerling for 0.06 cedi, 5.0 g fingerling for 0.10 cedi each with free packing and oxygen (source: website of Volta Catch: http://www.voltacatch.com/Our%20Products.html accessed on 08-01-2015 at 16:00).

West African Fish Ltd is located at Lake Volta in the Eastern Region, near the small town of Asikuma. Hatcheries are constructed on the shores of Lake Volta with state-of-the art recirculation technologies to produce fingerlings with almost no water change. Fingerlings are bred from the companies own brood stock. Currently fingerlings are produced for only own use; soon they will be able to provide top quality fingerlings for other fish farmers, and for restocking Lake Volta.

Safeway Agro has a hatchery on the shores of Lake Volta in the South Dayi District for the production of tilapia fingerlings for his own use. The hatchery which is housed in a green house is operating on a recirculation system was designed by Til Aqua International and a team of technical consultants from India and has a production capacity of 3 million fingerlings per month (Rurangwa, 2014).

Other small scale fingerling producers include:

- Ainoo-Ansah Farms: commercial monosex tilapia hatchery producing fry and fingerling
- Integrated Aqualife Village near Kumasi, supply tilapia and catfish fingerlings

While cage farms use all-male tilapia in monoculture, pond farmers use both all-male and mixed-sex tilapia, sometimes in mixed culture with catfish and mudfish (*Heterobranchus spp*.), snake head (*Channa striata*), Heterotis (*Heterotis niloticus*), and other endemic species. They obtain tilapia and catfish fingerlings from public and private hatcheries, from other farmers, and from the wild for endemic species.

The lack of high quality fingerlings in reliable volumes is shared by many stakeholders we have interviewed, including those not directly involved in fish farming. Another problem raised by 2 interviewees, Mr Bae and Mr Lee, is the lack of suitable farming sites in Lake Volta.

The supply of fingerlings from public and private hatcheries has increased exponentially since 2005 from 6,844,900 (Kassam et al., 2014) to 130,127,500 fingerlings in 2013 (MOFAD, 2014), with a big contribution from private hatcheries. Production from the private sector constituted 96% of the total production for the period while production from the public sector (Pilot Aquaculture Center, Ashiaman Demonstration Center and CSIR-WRI/ARDEC) constituted 4%. Fingerlings supply by different hatcheries in 2013 is presented in Table 3.

Table 3. Fingerling supplied by different private and public hatcheries in 2013 (MOFAD, 2014)

Hatchery per region	Fingerlings supplied	Fish species produced
Greater Accra	51,120,000	
Ashaiman*	2,100,000	Tilapia
Best Choice Farms	60,000	Tilapia
Blue Star farms	2,400,000	Tilapia
Greenfields Farms	360,000	Tilapia
Tropo Farms	40,000,000	Tilapia
Fishreit Farms	25,000,000	Tilapia
Oceaba Farms	960,000	Tilapia
Catfish Ghana Limited	240,000	Catfish
Eastern	30,722,500	
CSIR-WRI (ARDEC)*	2,000,000	Tilapia
Crystal Lake	24,400,000	Tilapia
West African Fish Ltd	1,657,000	Tilapia
Sunwoo culturing systems	1,865,500	Tilapia
U.S Microfinance Farms	800,000	Tilapia
Volta	21,685,000	
Volta Farms Ltd	75,000	Tilapia
Mr. Moses Aklinogo	21,600,000	Tilapia
Central	3,618,000	
Ainoo Ansah Farms	2,400,000	Tilapia
Ambrose Farms Complex	18,000	Catfish
Obaapa Farms	200,000	Tilapia
African Project Development (APD) Holding	1,000,000	Tilapia & Catfish
Ashanti	2,767,000	
Pilot Aquaculture Center (PAC)*	86,000	Tilapia
KMA Zone	1,520,000	Tilapia
ATWIMA Zone	150,000	Tilapia
SEKYERE Zone	86,000	Tilapia
AHAFO OFINSO Zone	900,000	Tilapia
ADANSI Zone	25,000	Tilapia
Western Zone	225,000	
Mr. John Kpemli	70,000	Tilapia
Mr. John Kpemli	155,000	Catfish
Grand Total	130,127,500	

*Public hatcheries

5.4 Fertilizers

The majority of pond aquaculture is semi-intensive and many fish pond farmers apply organic manures such as chicken droppings, pig and cow dung. Very few apply inorganic fertilizers (hydrated lime).

5.5 Capital

Capital investment/financial base continue to be a major challenge particularly for the small and medium scale farms. Large commercial aquafarms, largely owned by foreign investors, attracted foreign direct funding for their set-ups and operations. Few local banks have specific interests in financing aquaculture projects. The locally owned Prudential Bank Ltd, Ghana, has a specific interest in agricultural and small business sectors and has shown interest to cooperate in aquaculture projects, especially targeting small to medium enterprises (Kaunda et al., 2010). The Prudential Bank, operating since 1993, has a mission to *'provide domestic and international banking services with a strategic focus on project financing and export development'*. The Agricultural Development Bank has also provided support to one smaller farm and the Merchant Bank and regional Stanbic Bank have also shown interest but are still to get involved. More generally, the banks are apparently rather reluctant to get involved in the aquaculture sector, in spite of the obvious enthusiasm of the Government of Ghana and of various individuals. They argue that the sector suffers from a lack of management and have little knowledge of potential cash flows. Stanbic did however express interest into getting involved in processing businesses. The Agricultural Development Bank seem to have stopped financing aquaculture projects due to high default rate (Kaunda et al., 2010). Generally local banks are unwilling to support aquaculture start-up businesses. The Government of Ghana shows and demonstrates greater commitment to creating enabling environments, and direct support to aqua farming business operations in Ghana. Government is still creating opportunities for small and medium scale businesses, including aqua-businesses, to harness competitive funding facilities such as the Skills Development Fund (SDF) to either upgrade or acquire technology or skill to enhance efficiency and improve productivity. Currently, MOFAD, through a World Bank facility of West Africa Regional Fisheries Program (WARFP), is funding a feasibility assessment to enable development of aqua farming business models that will lead to competitive direct funding of aquaculture business start-ups.

5.6 Knowledge

Four public Universities, notably, University of Ghana (UG), University of Cape Coast (UCC), Kwame Nkrumah University of Science and Technology (KNUST) and University of Development Studies (UDS) conduct research and are directly involved in tertiary training of personnel in aquaculture and related subjects at the levels of BSc, MPhil/MSc and PhD (Table 4). Technical knowledge in aquaculture is also provided at Agriculture Colleges to potential Technical and Extension Officers, who usually work as field assistants at MOFAD, Research Institutions and Fish Farms. The CSIR - Water Research Institute (WRI) is the only public research institution with mandate to conduct research and development in and Aquaculture. WRI is actively involved in building capacities, both locally and within the West African region, of farmers, MOFAD fisheries officers, university students through part-time tuition and National Service Personnel attached to the Institute. Successful National Service persons from WRI usually get engaged to assist in technical management of most farms including large commercial farms. Knowledge in aquaculture is also developed through regular industrial attachments of interested persons to WRI or some functional commercial farms.

6 Institutions, policy and legislation

6.1 Institutions

Institutions involved with fisheries and aquaculture activities include:

- Ministry of Fisheries and Aquaculture Development (MOFAD), through the Fisheries Commission.
- Water Research Institute, Aquaculture Research and Development Centre in Akosombo.
- FAO Regional and Country Offices.

The WRI is the only aquaculture research institution in the country, although the universities also carry out some research into aquaculture. The WRI with PhDs (13), M.Sc (5) and B.Sc (1) degree holders has expertise in the fields of aquaculture, fish genetics, fish breeding, fish biology, fisheries management, biological sciences and agricultural economics (Asmah, 2008).

Training in aquaculture is available at three universities and an agricultural college (Table 4). None of the technical schools in the country offers aquaculture training.

Table 4. Government institutions associated with aquaculture research and training.

Institution	Purpose	Degrees Awarded	Key personnel	Area of specialization of key personnel
Kwame Nkrumah University of Science and Technology (KNUST) - Renewable Natural Resources	Training	Ph.D., M.Sc., B.Sc	Ph.D. (1), M.Sc. (4)	Aquaculture, fish nutrition, ichthyology, water resources management, freshwater ecology, biodiversity
University of Ghana (UG) -Department of Marine and Fisheries Sciences	Training	PhD M.Phil., B.Sc.	Ph.D. (2), M.Sc. (3)	Freshwater and brackishwater aquaculture, fish Health
University of Cape Coast (UCC) -Department of Fisheries and Aquatic Sciences	Training	Ph.D., M.Phil., B.Sc.	Ph.D. (3), M.Phil. (1), B.Sc.	Fisheries, aquaculture, biology and culture of shellfish, fisheries biology and conservation of marine mammals
Council for Scientific and Industrial Research (CSIR) -Water Research Institute	Research	-	Ph.D. (7), M.Sc. (6), B.Sc. (3)	Aquaculture, genetics, fish breeding, fish biology, fisheries management, biological sciences and agricultural economics
Kwadaso Agricultural College	Training	Agricultural Certificate	B.Sc. (2)	Aquaculture, natural resources development and general agriculture
Ministry of Food and Agriculture	Development agency	-	M.Sc. (8), B.Sc. (10), Dip. (4)	Aquaculture, shrimp and bivalve culture, hatchery management, fish health and extension.

Source: FAO (2004). National Aquaculture Sector Overview - Ghana

Directorate of Fisheries; Kwame Nkrumah University of Science and Technology; Univ. of Ghana; Univ. of Cape Coast; Kwadaso Agricultural College; WRI Annual Report, 2013; DoF.

Professional organisations in fisheries and aquaculture are:

- National Fisheries Association of Ghana (NAFAG) is the umbrella organisation of fishermen and fish farmers in Ghana.
- Ghana Aquaculture Association (GAA) groups producers, suppliers, Service industry, Markets based members supporting development of aquaculture in Ghana.
- Asuogyaman zone fish farmers association (AZOFFA) in Lake Volta.
- Fish farmers association, producers association in different regions.

6.2 Policy and legislation

Aquaculture practice in Ghana is regulated by the Fisheries Act, 2002 (Act 625) and the Fisheries Regulation, 2010 (L.I.1968). The Fisheries Act of 2002 is the main legislative instrument, while the Fisheries Regulations of 2010 are the main support measures for the fisheries and aquaculture sectors. The regulations covers various aspects of aquaculture: inputs such as seed, seed production certification, responsible aquaculture practices, import of live fish and transfer of fish within the country.

Aquaculture falls under the Ministry of Fisheries and Aquaculture Development, established since 2013 from the formal Ministry of Food and Agriculture. The Ministry collaborates with other agencies and institutions such as the Environmental Protection Agency (EPA), Volta River Authority, the Ghana Standard Board in the execution of its mandate including the licensing of aquaculture permits (Figure 8), the certification of hatcheries.

- The Environment Protection Agency (EPA) grants licences based on environmental impact assessments required by fish farmers. The Environment Protection Agency Act of 1994 ensures that aquaculture projects do not damage the environment. The Environment Assessment Regulations of 1999 require both land-based and cage aquaculture activities to undergo impact assessments.
- The Fisheries Commission has produced the GNADP with contributions from the private sector-led Aquaculture Advisory Group and technical support from the FAO regional office for Africa based in Accra.
- The Water Resources Commission regulates and manages the use of water for any activity.
- The Volta River Authority (VRA) is in charge of hydro-electricity production and management of the Lake and its catchment area. Transportation on the lake is a subsidiary activity of the Volta Lake Transport Company.

Before starting procedures to acquire different permits (Figure 8), it is important to preliminarily:

- Discuss the project with the fisheries commission
- Seek advice for site selection (zoned for aquaculture, no land litigation)
- Develop a business plan
- Register the company at registrar general's department
- Acquire a land with legal titles from right owners

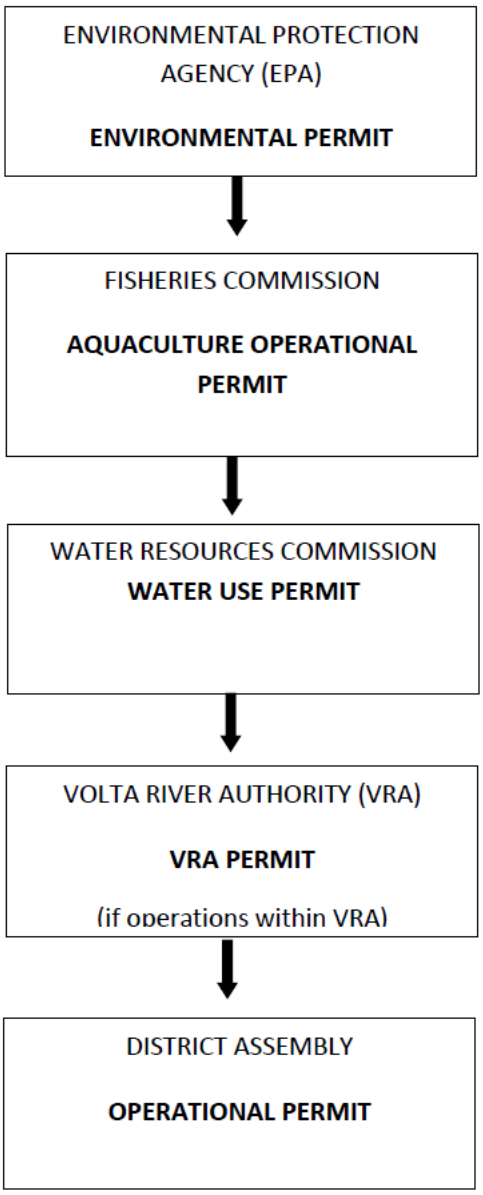

Figure 8. Flow chart of procedures, institutions involved and permits to establish a fish farm

Depending on the type of aquaculture related activities, for example the establishment of a fish feed factory, other types of permits may be required. For hatcheries, certifications are additionally requested from the Fisheries Commission.

Within Ghana Fisheries and Aquaculture Policy, the growth of aquaculture is highly desirable as expressed in the objective of the policy which is to "contribute to socio-economic development through food and nutritional security and poverty reduction in a sustainable and economically efficient manner, within the natural limits of capture fisheries resources and environmental protection requirements, and with strongly established basis for accelerated growth in aquaculture production".

The legal framework allows for environmentally-responsible aquaculture development in Ghana where an aquaculture project is required to have a license which is not transferable, and whose application shall be accompanied with an environmental impact assessment. In addition, a licensed aquaculture operator

shall carry out the operations in conformity with prescribed standards relating to aquatic environmental protection, quality of produce and hygienic methods.

Within the legal framework aquaculture is defined as "any activity designed to cultivate or farm fish and other living aquatic resources" and does not define the size and scope of aquaculture for which EIA has to be conducted. Currently the Commission for Environmental Protection Agency does grant a licence after consultation with the Fisheries Commission and other stakeholders e.g. District Assembly.

7 Bottlenecks and opportunities

7.1 Bottlenecks

From the VCA a number of essential bottlenecks have been identified. The main bottleneck for Tilapia farming in Ghana is that production costs are too high. In other words, current supply of Tilapia cannot meet the demand. This hampers the sector from its sustained expansion.

A first major bottleneck is feed. Imported fish feed is very expensive compared to local feed. This relates foremost to unfavorable exchange rates. Imported feed is app. 30% more expensive than local feed. A bottleneck can also be found in local feed production, which is currently at its maximum capacity. In addition local feed production experiences a bottleneck due to its dependency on imported ingredients and thus a lack of reliable volumes and affordable local ingredients.

There is also a major bottleneck in fingerling production because supply cannot meet demand. Moreover high mortality rates make fingerling production relatively inefficient. This may also relate to another bottleneck which is the local Akosombo strain. Although breeding programmes have somewhat improved the performance of the Akosombo strain, it does not perform as well as the GIFT strain. However, the introduction of GIFT experiences a bottleneck due to unfinished environmental impact assessment and therefore a lack of a solid base for decision-making at the governmental level.

At the farm level the VCA has illustrated two bottlenecks. The first bottleneck is a lack of skilled labor and therefore inefficient farm practices, such as feeding practices and monitoring of water quality. Water quality is also a major bottleneck in specific locations of Lake Volta. During certain seasons oxygen levels in water are too low. Other suitable sites are available but complex licensing procedures and bureaucracy delay the reallocation of farms. On the financial side aquaculture farms also experience a lack of access to capital and high interest rates (23-30%) on bank loans. Although this bottleneck is not specifically applicable to aquaculture, it still affects the sustained expansion of the sector.

7.2 Opportunities

In Ghana, pond aquaculture is not developed as cage farming and, if supported, may have certain advantages since ponds do not need expensive feeds, as fish can partly feed on natural food available in the ponds. Currently, cage aquaculture shows a more sustained growth than pond aquaculture. Vertical integration of input supply, local aqua feed production, production of quality fingerlings in controlled conditions for safety and whole year-round intensive production of fingerlings constitute the basis of a solid cage farming industry. By ensuring affordable key inputs, existing cage farmers and new SME cage farmers can benefit from such new investments. These opportunities are developed in chapter 8 into profitable business cases for the private sector investment. Other possible investments could be the capacity building and the transfer of knowledge to develop appropriate skills that are currently lacking at different levels of the aquaculture sector. The economical results of farms is not only dependent on the survival and growth rate of the fish strain and the FCR as usual, but depends also on the skills of the labour and management of the farm, according to cage fish farmers interviewed. This makes capacity building and skill development at the fish farm level a necessity.

8 Business cases

During a field mission to Ghana in February 2015 a study was conducted to assess the feasibility of the formation and the set-up of Public Private Partnerships (PPPs) for fish farming in Ghana. A comprehensive aquaculture Value Chain Analysis (VCA) was carried out to identify business opportunities and to develop business cases where Dutch companies could play a role.

8.1 Business case 1: Fish Feed Mill

Background

It is projected that Tilapia cage farming output in Ghana will increase with several thousand tons per year. Current production is app. 40,000 tons. With an FCR of app. 1.7 a total of 68,000 tons of feed is required to produce 40,000 tons of Tilapia. There is only one specialised local aqua feed mill, namely Raanan. This company produces 25,000 tons annually for the Ghanaian market. However Raanan is currently producing at its maximum capacity. This implies that 43,000 tons of feed is imported and produced locally by non-dedicated feed mills and on-farm by the farmers. However the locally produced feeds are very poor in quality as they are not extruded for example. Imported feed is app. 30% more expensive than locally produced Raanan feed so importation does not offer a solution. On average the costs for Tilapia farming in Ghana consists of 70% of feed cost.

Market needs

To facilitate the growth in Tilapia farming and to reduce the production costs, the industry needs more feed with reliable volumes, a stable price and of a good quality. In the near future a new feed mill is needed in order to meet the feed demand from Tilapia farming. Potentially there is already a market of 20-30 thousand tons, the amount of feed that is currently imported. With cheaper locally available high quality feed, fish production is going to be boosted.

For hatcheries there is a specific need for high protein feed (45%). Coppens is currently importing this type of feed into Ghana for a relatively high price. A local feed mill would also introduce more competitiveness in feed production as Raanan is currently having a monopoly position in the market and in spite of its much lower selling price than imported feeds operates with very high gross margins on its sales. Ceteris paribus, more competitiveness will lower the feed prices which will be in favour of the hatcheries and cage farms.

Cost/benefit analysis

In the table 5 below we project a feed mill with effective capacity of 4 tons per hour (extruder of 5 tons per hour). Annually, at full capacity, the output of the feed mill will be app. 30,000 tons. The investments are best estimates of the installation costs of a production plant utilising modern (Western) equipment amounting to 4,2 million US$. Operational costs are based on experience in running such a facility, adapted to local conditions and costs. The margins are determined based on model formulations, current market prices for ingredients and present market prices for the final product. Gross margin used in the calculation is app. 60% of the estimated actual margins of Raanan feed.

Table 5. Calculations of the Fish Feed Mill

	Production in tons/Yr	Total sales US$	Cost of goods sold US$/ton	Gross margin US$/ton	Total Gross margin US$/Yr	Total Operational costs US$/Yr	Marketing expenses US$/Yr	Admin. costs US$/Yr	Net Operating Income US$/Yr	Working capital in US$	Interest US$/Yr	Deprec. 20 yrs US$/Yr	Net profit US$/Yr
1 shift (8 hrs)	8,000	5,600,250	700	250	2,000,000	984,000	100,000	25,000	**891,000**	1,400,000	560,000	210,000	**121,000**
2 shifts (16 hrs)	16,000	11,200,250	700	250	4,000,000	1,566,000	150,000	35,000	**2,249,000**	2,800,000	700,000	210,000	**1,339,000**
3 shifts (24 hrs) 5d/wk	25,000	17,500,250	700	250	6,250,000	2,166,600	200,000	40,000	**3,843,400**	4,375,000	857,500	210,000	**2,775,900**
4 shifts (24 hrs) 5d/wk	32,000	22,400,250	700	250	8,000,000	2,683,200	200,000	45,000	**5,071,800**	5,600,000	980,000	210,000	**3,881,800**

SWOT analysis

In the table 6 below a short SWOT analysis is presented. From table 5 we can conclude that the need for feed is certainly there and that an additional feed mill is for sure a very good business opportunity. However the success of an additional feed mill depends on the local availability of quality feed ingredients and bottlenecks further in the value chain. The first most important bottleneck is a reliable quantity and quality of fingerlings. The second most important bottleneck is the lack of knowledge and skills with locally owned farms.

Table 6. SWOT analysis Fish Feed Mill

Strengths	Weaknesses	Opportunities	Threats
Calculations illustrate need for feed mill	Quality and quantity of fingerling production	High demand for Tilapia in Ghana	Fluctuations in local currency
Dutch Aquaculture Experts and Foot Tech Africa are strong public-private partnerships, eager to do business in Africa	Highly dependent on import of expensive ingredients	Raanan feed mill already at full capacity. Cannot meet future demand	No reliable quantity and quality of local ingredients
Infrastructure and research facilities available at CSIR-Water Research Institute	Only few professional foreign owned farms.	Imported feed is 30% more expensive than local feed	Legal uncertainties and bureaucracy with respect to decision making and investments
Available local feed expertise and labour	Lack of knowledge and skills with locally owned farms	Aquaculture likely to grow in the region (e.g. Nigeria). Potential for exporting feed.	Competition with parallel fish feed investors
Stable democratic governance and Government's conducive policies and support	Lack of infrastructure hampers development of new farms and influences transport	5 years Tax holidays for agro-business start-ups	
Available Fertile lands and Existing strong farmer cooperatives for out-grower schemes of feed ingredients (e.g. maize, soybean, cassava)			

Next steps

To bring this business case to the next level it is proposed to share the current case with Dutch private companies active in feed production.

8.2 Business case 2: Hatchery

Background

Currently there is no reliable supply of good quality fry and fingerlings to the outgrowing farms. The VCA illustrates that existing hatcheries cannot meet the market demand in terms of quantity and quality of fingerlings due to a lack of knowledge and experience, lack of equipment and logistics that are not optimised. This is one of the major bottlenecks to boost the Tilapia farming in Ghana.

Market needs

To facilitate the growth in Tilapia farming outgrowing farms urgently need a reliable supply of good quality fry and fingerlings. Presently it is estimated that there is a lack of 50 million fingerlings. There is an excellent opportunity for a new hatchery that can produce these quantities reliably.

Cost/benefit analysis

For the business case two options were developed. One focusing on ponds (Table 7) and another focusing on Recirculation Aquaculture Systems (RAS) (Table 8). Specifically the second case considers the option of introducing fully controlled conditions of producing improved tilapia strains in Ghana. In the tables 7 and 8 below a 50 million pieces per year fingerling production is projected in ponds and RAS, respectively.

The investments are best estimates of the installation costs of a hatchery & nursery utilizing modern equipment in the RAS option. Investment costs for a pond based hatchery is estimated at 1,3 million US$ and the RAS option at 3,1 million US$. Operational costs are based on experience in running either a pond based farm or a RAS respectively, adapted to local conditions and costs. For both options the total sales are projected based on current market prices for 5 g Tilapia fingerlings.

Table 7. Hatchery and grow-out using ponds

	Number of fingerlings per year	Total sales US$	Total Operational costs in US$/Yr	Marketing expenses in US$/Yr	Net Operating Income in US$/Yr	Working capital in US$	Interest 10% US$/Yr	Depreciation US$/Yr	Net profit US$/Yr
Grow-out (5 g)	50,000,000	3,030,303	1,271,560	50,000	1,758,743	500,000	134,500	103,462	1,520,781

Table 8. Hatchery and grow-out using RAS

	Number of fingerlings per year	Total sales US$	Total Operational costs in US$/Yr	Marketing expenses in US$/Yr	Net Operating Income in US$/Yr	Working capital in US$	Interest 10% US$/Yr	Depreciation US$/Yr	Net profit US$/Yr
Grow-out (5 g)	50,000,000	3,030,303	1,296,485	50,000	1,733,818	500,000	366,250	263,542	1,104,026

In the projections the profitability of RAS is lower due to a much higher investment. However, the level of control and biosecurity in the RAS farm is also higher.

SWOT analysis

In the table 9 below a short SWOT analysis is presented. From table 5 we can conclude that the need for feed is certainly there and that an additional feed mill is surely a very good business opportunity. However the success of an additional feed mill depends on the local availability of quality feed ingredients and bottlenecks further in the value chain. Other important bottlenecks are the shortage in reliable quantity and quality of fingerlings and the lack of knowledge and skills of locally owned fish farms.

Table 9. SWOT analysis Hatchery

Strengths	Weaknesses	Opportunities	Threats
Calculations illustrate need for a hatchery	Only few professional foreign owned cage farms.	High demand for Tilapia in Ghana	Legal uncertainties and bureaucracy with respect to decision making and investments
Dutch Aquaculture Experts (DAE) and FoodTechAfrica (FTA) are strong public-private partnerships, eager to do business in Africa	Lack of knowledge and skills with locally owned cage farms. Production is low.	Low quality and quantity of current fingerling production	Competition with parallel hatchery investors, own hatchery setups by commercial farms
Infrastructure and research facilities available at CSIR-Water Research Institute	Hormone use for sex reversal poses a risk for human health and impacts immune system of Tilapia	High unemployment of youth	
Stable democratic governance and Government's conducive policies and support	Lack of infrastructure hampers development of new farms and influences transport	5 years Tax holidays for agro-business start-ups	
Conducive Land and available water resources			

Next steps
To bring this business case to the next level it is proposed to share the current case with Dutch private companies active in hatcheries, nursery and/or have a more general interest in fish farming in Ghana.

8.3 Business case 3: Training and Education

Background
From the report it is clear that especially local cage farmers experience a lack of knowledge and skills in order to work towards profitable Tilapia farming. This constraint is partly responsible for the app. 1,200 empty cages recently abandoned in the Volta Lake, which were formerly owned by local producers. Knowledge base and skill training of fish farmers is strongly being advocated by MOFAD.

Market needs
Relative to other agribusiness sectors, very few Ghanaians are involved in the fish farming enterprise. Official statistics from the 2010 Ghana Housing and Population Census indicate that only 0.22% of the Ghanaian population is involved in fish farming as an agricultural activity. This situation has arisen because, firstly aqua farming business is fairly recent, and secondly, the interest of prospective and present fish farmers in Ghana remains grossly underserved despite the high numbers of individuals and private companies that have expressed interest in training and investment schemes in fish farming. However, the interest of Ghanaians into fish farming keeps growing yearly as evident in the growth of aqua farms and aquaculture production in recent times (Table 1 and Figures 4&5). It is for this reason

that the Government of Ghana in collaboration with some local institutions and development partners has over the years initiated a number of policies, regulations and programmes to promote and develop the aquaculture industry in Ghana. As Government places much importance of aquaculture to its GDP growth and the provision of food to meet food security needs, many new entrants are expected into the industry, while existing players will need strengthening of their capacities to ensure increased aquaculture production. At the recent stakeholder meeting with MOFAD, Research and Industry in Accra on 26th February 2015, it was recommended that training of farmers take center stage in order to ensure a desirable growth and development of aquaculture in the country. Four hundreds cage fish farmers can be trained each year (Table 10). In Table 11, a short SWOT analysis of the training and education is presented.

Cost/benefit analysis

Table 10. Training and Education

	Number of farms/Yr	Number of farmers/Yr	Training costs (US$)	Gross Revenue (US$)	Net Income (US$)
Skills Development	100	400	400,000	850,000	450,000

SWOT analysis

Table 11. SWOT analysis Training and Education

Strengths	Weaknesses	Opportunities	Threats
Dutch Aquaculture Experts and Foot Tech Africa are strong public-private partnerships, eager to do business in Africa	From a business perspective Training and Education are less attractive to invest in. Partly dependent on government funding/subsidies.	High demand for Tilapia in Ghana	Funding challenges by Farmers
Local knowledge, Infrastructure and research facilities available at CSIR-Water Research Institute		Also small-holders using pond systems can be included in a Training and Education programme	
Identified bodies of fish farmers e.g. Ghana Aquaculture Association (GAA) and Asuogyaman Zone Fish Farmers Association (AZOFFA)		National program support e.g. Ghana Youth Employment and Entrepreneurial Development Agency (GYEEDA), for youth in agriculture/aquaculture	
		Establish a cooperative organisation where local and foreign farmers can exchange skills and knowledge	

Next steps

To bring this business case to the next level it is proposed to share the current case with Dutch private companies and knowledge institutes such as Wageningen UR active in training and education, capacity building and skills development, transfer of technology and knowledge.

8.4 Follow-up and implementation of the business cases

Companies interested in any of these business cases can contact the Economic and Agriculture department of the Dutch Embassy in Accra or the authors of this report to develop a proposal and to conduct a more detailed in-depth study of that specific business cases. Such a proposal may firstly focus on the feasibility of the business case, identifying opportunities and constraints for the implementation.

Embassy of the Kingdom of the Netherlands
89 Liberation Road, Ako Adjei Interchange, Accra, Ghana
w: ghana.nlembassy.org

Thierry van Helden, First Secretary
e: Thierry-van.Helden@minbuza.nl
t: +233 302 214 363
f: +233 302 773 655

Mariska Lammers, Trade and Information Officer
e: m.lammers@minbuza.nl
t: +233 302 214 350
m: +233 260 519 159

Funding instruments
Interested companies can also use one of the funding instruments available in The Netherlands:

- The DHK subsidy of RVO to carry out a feasibility study: http://www.rvo.nl/subsidies-regelingen/subsidieregeling-voor-demonstratieprojecten-haalbaarheidsstudies-en-kennisverwerving-dhk,
- The Dutch Good Growth Fund for Dutch SMEs with interests to invest in emerging economies http://www.rvo.nl/subsidies-regelingen/dutch-good-growth-fund-dggf,
- The public private partnership of the Top Sector Agri&Food (http://www.tki-agrifood.nl).

9 Conclusions

The main aim of this study was to assess the feasibility of the formation and set-up of one or more Public Private Partnerships (PPPs) for aquaculture in Ghana. The project consisted of two phases. The first phase was a value chain analysis (VCA) of aquaculture in Ghana to identify bottlenecks and business opportunities. The second phase was to develop business cases for investments in aquaculture in Ghana.

Value chain analysis
Starting with the demand side of the value chain it is clear that there is a business opportunity in general due to the high demand for Tilapia in Ghana from a consumer perspective. App. 25 kg of fish and fishery products per capita are consumed annually in Ghana, with fish accounting for 60% of the national dietary animal protein. Despite the relatively high prices of US$ 2.50 to over US$ 3.00 per kilo, Tilapia has become one of the most important and highly demanded animal protein in the rural and urban centers of Ghana. This implies that Tilapia is a product sold to the upper middle class and higher class in the society of Ghana. Lower classes cannot afford the product. Demand for cultivated Tilapia and other species in aquaculture may rise in the next decade due to declining production from capture fisheries.

The value chain analysis illustrates a bottleneck in existing hatcheries, because they cannot meet the market demand in terms of quantity and quality of fingerlings due to a lack of knowledge and experience, lack of equipment and logistics that are not optimised. If Tilapia production is to increase in Ghana, this lack of fingerlings is a bottleneck that needs to be solved as soon as possible.

Considering feed production, there is only one major local feed manufacture (Raanan) that produces annually 25,000 tons of fish feed for aquaculture in Ghana. Currently the feed mill is running at its maximum capacity. Importing companies of aqua feeds include Multifeed, Coppens, Skretting and Cargill. Imported feeds are 30% more expensive compared to local feeds which made Raanan feeds popular in many farms. Due to the devaluation of the Ghanaian cedi (GH¢) the competitiveness of imported feed decreases. Tilapia aqua feed imported in Ghana increased from 21.5 tons in 2006 to 518.7 tons in 2009. This implies that there is a bottleneck in the supply of feed that cannot meet the demand. Based on our analysis in the business case on local feed production, we foresee a business opportunity with a potential of 30,000 tons per year of additional local feed production in Ghana.

Cage farming is by large the most important production method of Tilapia in Ghana, with 33,000 tons mainly from Lake Volta in 2014. Tilapia production in cages in the lake had a growth over 500% since 2009. There are currently six large farms: West African Fish Ltd (Denmark), Tropo Farms (Nigeria/Germany), Sunwoo (Korea), Maleka (Lebanon), Triton (India) and Lee's Farm (Taiwan). The main bottlenecks for these farms are the high price of feed, the lack of fingerlings and qualified employees. Also a major bottleneck occurs in the southern part of Lake Volta and specifically in shallow side channels, due to a lack of oxygen during February and July, August and September. These farms experience another bottleneck in getting permission to access sites with more favourable conditions.

In Ghana only the local Akosombo strain of Tilapia can legally be cultivated. An opportunity is another more performant Tilapia strain. The Genetically Improved Farmed Tilapia (GIFT) is already present at CSIR only for research purposes but has not been released for culture yet. Most respondents are in favour of the introduction of GIFT due to strong indications of about 50% faster growth (specific growth rate) than the Akosombo strain. An environmental risk assessment has not been completed. This results in a bottleneck in decision-making with governmental agencies, which cannot be completed.

The Ghana National Aquaculture Development Plan (GNADP) is a highly ambitious plan of the government. Production should boost from 10,200 tons in 2010 to 100,000 tons in 2016. However the

21 projects to implement the Plan have not been conducted so far due to a lack of funding. A bottleneck is present in complex procedures for licenses. These procedures are bureaucratic and can take up to 1 or 2 years. Five to six governmental agencies are involved but do not efficiently cooperate.

Based on our findings we conclude that the main bottlenecks in Tilapia farming in Ghana is the production costs which are relatively high in comparison to other countries. The bottlenecks are the high costs of imported aqua feeds; the lack of reliable volumes of local ingredients for feed; the dependence on import of ingredients for feed; a lack of quality fingerlings in reliable volumes; poor performance of the local Tilapia strain; lack of skilled labour and appropriate technologies; devaluation of the GH¢ and its impact on prices of imported inputs; and high interest rates for bank loans.

From the findings we can also conclude that there are a number of opportunities for Dutch businesses. Investments are interesting in the vertical integration of input supply. Local aqua feed production, production of quality fingerlings in controlled conditions for safety and whole year-round intensive production of fingerlings constitute the basis of a solid cage farming industry. By ensuring affordable key inputs, existing cage farmers and new SME cage farmers can benefit from such new investments. Two identified opportunities are further elaborated into two business cases. A third business case for which in-depth data and information is lacking is suggested for further development in follow-up projects. A potential business case on the production of Tilapia fillets from fish over 600 g merits to be mentioned but is not elaborated in this report. Bigger tilapia are not easily sold on close markets near production sites. They are taken by hotels in big cities. Such a business case needs to be developed in a different assignment during which data on volumes available, costs and markets can be collected.

Business cases
The first business case developed is local feed production. To facilitate the growth of Tilapia farming industry and to improve economic potential of the farms, more feed of reliable quality and economic price is needed. The current capacity of Raanan, the most important feed producer today, doesn't meet this requirement. There is a market for a feed mill with a capacity of 20-30,000 tons of feed annually.

The second business case is Tilapia fingerling production. Currently there is no reliable supply of good quality and quantity fingerlings to the outgrowing farms which hampers the expansion of existing farms. Presently it is estimated that there is a lack of 50 million fingerlings annually. There is an excellent opportunity for a new hatchery that can produce these quantities of good quality fingerlings.

The third business case is training and education in best fish farming practices at the farm level. The management of some farms is not optimal because of unskilled employees, some farm managers and owners of small- and medium-scale farms, who do not possess the right knowledge.

These business cases will be publically shared with potential Dutch investors. If companies are interested in any of them a proposal will be developed. Such a proposal will focus on a more detailed in-depth study of the proposed business cases.

Annex 1 – Aquaculture production in Ghana per system and per region

Region	Pond aquaculture			Cage aquaculture			Other (dugouts, reservoirs, dams)	All sources
	# ponds	Area (ha)	Production (tonnes)	# cages	Volume (m^3)	Production (tonnes)	Production (tonnes)	Production (tonnes)
Greater Accra	275	75	201	350	43750	2731	0	2932
Ashanti	1205	151	585	39	4875	30	0	615
Northern	90	3	2.7	0	0	0	520	523
Eastern	292	30	252	1473	179223	21500	0	21752
Brong Ahafo	1393	65	290	0	0	0	0	290
Western	644	83	250	3	225	20	0	270
Upper East	49	13	50	0	0	0	599	649
Upper West	17	1	20	10	1000	2	339	361
Volta	247	98	498.5	416	50900	4200	0	4698.5
Central	537	185	421	0	0	0	0	421
Total	4749	704	2570	2278	27973	28483	1459	32512

Source: MOFAD (2013).

Annex 2 – Raanan feed price list (August 2014)

Name	Product	Pellet size (mm)	Fish size (g)	Protein/Fat content (%)	Price/kg (GH¢/kg)
Super Starter	SS 0	0.2-0.3	0.01->0.2	58/10	8.65
	SS 1	0.3-0.5	0.2->0.5	56/11	8.55
	SS 2	0.5-0.8	0.5->0.9	56/11	8.45
	SS 3	0.8-1.2	1->3	55/13	8.35
	SS 4	1.2-1.5	3->10	55/13	8.35
Tilapia Prime Starter	TC 1	0.3-0.5	0.2->0.5	48/5	5.05
	TC 2	0.5-0.8	0.5->0.9	48/5	5.05
	TC 3	0.8-1.2	1->3	48/5	5.05
	TC 4	1.2-1.5	3->10	48/5	5.05
Pre Grower	PG40 S	Crumble	5->40	40/5	3.95
Tilapia High Growth	High growth	2.2	20->70	38/8	3.85
	High growth	3	70->100	38/8	3.70
	High Growth	4	100->200	38/8	3.60
Tilapia Supreme Growth	Supreme growth	2.5	30->90	33/8	3.50
	Supreme growth	4.5	90->200	33/8	3.25
	Supreme growth	6	200->500	33/8	3.25
Tilapia Prime Growth	Prime grower	4.5	90->200	30/6	3.10
	Prime grower	6	200->500	30/6	3.10
	ECO finisher	6	300->500	27/5	2.95
Catfish Supreme Growth	Grower feed	4.5	120->250	42/42	4.33
	Grower feed	6	250->500	42/12	4.33
	Grower feed	8	500->1000	42/12	4.33
Catfish High Growth	Grower feed	2.5	20->70	45/12	4.80
	Grower feed	3.3	70->120	45/12	4.67
	Grower feed	4.5	120->250	45/12	4.53
	Grower feed	6	250->500	45/12	4.53

Tilapia feed is packed in 20 kg bags while catfish feed is packed in 15 kg bags. Prices were collected at a warehouse in Tema, excluding delivery cost. Price reduction is per number of bags for total order (can be from mix of products).

Annex 3 – Potentially interested Ghanaian and Dutch partners in new investments

Ghanaian partners interested to invest in aquaculture

A number of Ghanaians have shown interest in new investments in aquaculture ranging from hatchery, feed mill plan, expansion of farms and training in aquaculture (see table below: Annex 3.1.).

Annex 3.1. List of Ghanaian partners with expressed interest in new investments in aquaculture

Partners	Investment type	Short description of the partner	Contact	Phone number	Email address
SAFOHENE LTD	Hatchery	Started hatchery and grow-out in 2008, but got incorporated in 2010. Currently stopped the hatchery due to difficulties in skills and funding. Grow-out capacity is 35 tons per year from 5 cages.	Mr Garbrah	+233249302905	francisgarbrah@yahoo.com
Crystal Lake Fish Limited	Hatchery expansion & management	Established since 2001. Biggest private tilapia fingerling production farm. Production capacity: 1-2 million fingerlings per week. Facilities also used to train farmers and fisheries officers.	Ms Patricia Safo	+233232961050	oliviasafo@gmail.com
Ainoo-Ansah Farms	Hatchery	Established since 2009. Adopted modern technology of recirculation aquaculture system (RAS) and green water technology (GWT). Production capacity: 1 million fingerlings per month, supply to 6 regions.	Mr Jacob Ainoo-Ansah	+233275406168 +233205550001 +233208137659	jainooansah@gmail.com
Flosell Farm Ltd	Hatchery & Grow-out production & feed production	Farm incorporated in 2010 and started operation in 2012. Hatchery capacity of 500,000 fingerlings per month. Grow-out capacity: 140 tons per year. Farm expects increased grow-out	Mr Evans Danso	+233244889584	Flosell@outlook.com. www.flosellfarms.com

		capacity to 1,000 tons per year. Interested in partnership for feed production of 10,000 tons per year, and a grow-out production to 1,000 tons fish per year.			
TATT Farms Ltd	Tilapia & Catfish hatchery and grow-out production. Expansion & Management	Established since 2008. Production capacity: catfish 60 tons per month; tilapia 120 tons per year. Seeks partnership for farm expansion and management.	Mr Godfred Lartey Gberbie	+233243514000 +233506807339	ataade@gmail.com www.fishking.com
Ghana Aquaculture Association (GAA)	Hatchery & feed mill plant	First established in 2009, and reconstituted in 2013. GAA is composed of practicing fish farmers, input suppliers, feed producers and fish marketers in Ghana. Seeks partnership for local feed production and hatchery operation to bridge feed and fingerling demand gap for its members in farming.	Mr Jacob Ainoo-Ansah	+233205550001	jainooansah@gmail.com, jainooansah@yahoo.com, pinnacle.bus.link@gmail.com
Asuogyaman Zone Fish Farmers Association (AZOFFA)	Tilapia hatchery & feed mill plant	Established more than 5 years ago. AZOFFA comprises fish producers, input producers and suppliers including fingerlings and feed producers, processors and marketers in Asuogyaman district and surrounding communities where cage culture is concentrated. Seek partnership for its members in feed production and hatchery production of tilapia fingerlings.	Mr Garbrah Mr Godfrey Alimo	+233249302905 +233244424397	francisgarbrah@yahoo.com s-hoint@hotmail.com

Sunwoo Culturing Systems	Farm move & expansion		Mr An Dong Bae	+233507240899	andong_bae@yahoo.com
Tropo Farms	Farm move & expansion		Mr Mark Amechi	+233202118212	tropoo@4u.com.gh
Safeway Agro	Farm expansion & training in aquaculture	Established tilapia grow-out production in 2011. Current capacity of 200 tons per year. Seek partnership for farm expansion and skill development.	Mr Jim Walter Foster	+233244643350	jim.walter@safewayestates.com

The Aquaculture Research and Development Centre (ARDEC) in Akosombo is part of the CSIR-Water Research Institute. It is a public research center in charge of aquaculture development in Ghana (CSIR-WRI, 2013). CSIR-WRI is a knowledge partner interested in a collaboration with Wageningen UR.
Contact: Dr. Seth Koranteng Agyakwah, t: +233343020786; m: +233244610181, +233204722445; agyaseth@yahoo.com, agyaseth@csir-water.com, info@csir-water.com

The potential interest of other Ghanaian actors in aquaculture could not be investigated, many of them having not been interviewed during the mission. Their contact details are provided in the table below (Annex 3.2.).

Annex 3.2. Contacts of other Ghanaian actors in aquaculture (from section 2.2.1)

Other actors in aquaculture	Contact	Phone number	Email address
Lee's Farm Ltd	Mr. Lee	+233202124946	
West African Fish Ltd	Mr. Lars Lynge	+233247931415 +4522100230	lars@westafricanfish.com
Maleka Farms	Mr. Roger Abujaoude	+233241511719	rabujaoude@gmail.com
Anson Farm	Mr. Owner Paul Anson	+233244673379	pewage1@yahoo.com
Aqua Farms Ltd	Raja A. Najjar	+233242610813	aquafarms@cctcgroup.com
Gilgal Farms Ltd	Mr. Bertrand Bonso-Bruce	+233244379025 +233204379022	bertrand.bruce@gmail.com
Dakuodeve Fish Farms			contact@dakuodevefishfarms.com
Kumah Farms Complex	Saiw Nana Kwaku Martin Kwaku Kumah	+233244537144 +233243756237 +233274609122 +233209276506	nana@kumahfarms.com, NanaKwakuSiaw@yahoo.com

Dutch aquaculture companies and knowledge institutes

Most Dutch aquaculture service providers and one knowledge institute are cooperating and united under Dutch Aquaculture Experts[5] where their products and expertise can be found. This is a group of highly qualified companies and a research institute that are working together to deliver aquaculture products and services in the Netherlands and all over the world. Delivered products and services include design, turn-key management, equipment, consultancy, fish feeds, fish stocks & broodstock, quality assessments, fish health services, contract research, and training.

IMARES (www.imares.nl)IMARES Wageningen UR is the Netherlands research institute established to provide the scientific support that is essential for developing policies and innovation in respect of the marine environment, fishery activities, aquaculture and the maritime sector.
Contact: Eugene Rurangwa, eugene.rurangwa@wur.nl

LEI (www.wageningenur.nl/lei)
LEI Wageningen UR is an independent and internationally leading socio-economic research institute. Its unique data, models and knowledge offer clients insights and integral advice for policy and decision-making processes in an innovative way, contributing to the creation of a more sustainable world.
Contact: Bas Bolman, bas.bolman@wur.nl

Aquaculture Experience (www.aquaculture-experience.com) is a consulting company with over 25 years of experience in the international aquaculture and aqua feed industry with its main focus on feed in the broadest sense of the word.
Contact: Hans Boon, hboon@aquaculture-experience.com

Catvis (www.catvis.nl)
Catvis designs and supplies recirculation systems for catfish and eel culture. At present Catvis is known as versatile, yet specialized, supplier to the international aquaculture industry, serving many companies throughout Europe, the Mediterranean countries and several areas in the world.
Contact: Martin Ooms, ooms@catvis.nl

Til Aqua International (www.til-aqua.com)
Til Aqua International is specialised in the production of Natural Male Tilapia (NMT) broodstock. The company sells naturally all male producing broodstock and their NMT fry. The company designs and builds tilapia hatcheries. The company has carried out projects in West Africa.
Contact: Eric Bink, info@til-aqua.com

Fleuren & Nooijen B.V. (www.fleuren–nooijen.nl)
Fleuren & Nooijen B.V. is specialised in design and construction of recirculation systems. Next to the culture systems, the company delivers a wide range of equipment and kits for fish farm management: water quality test kits, graders, spare materials, boots, brushes, cleaning and disinfectant agents. The company provides also consultancy in aquaculture. The company is also active in West Africa.
Contact: Bert Jan Roosendaal, b.j.roosendaal@fleuren-nooijen.nl

Aquaculture Consultancy & Engineering (ACE) (www.ace4all.com)
ACE is specialized in design and construction of recirculation systems for aquaculture farms, as well as the supply of equipment needed for these farms.
Contact: Rene Remmerswaal, rene.remmerswaal@gmail.com
Coppens International B.V. (www.coppens.com)

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5 www.dutch-aquaculture-experts.com

Coppens focuses on aquatic feeds. The company has experienced fish feed specialists, develops high-quality, innovative fish feed programs for almost every species of farmed fish in all their development stages. Coppens International is an active importer of fish feeds in West Africa.
Contact: Jeroen van Stokkom, Jeroen.vanStokkom@coppens.com

Skretting (www.skretting.com)
Skretting is a feed producer which is a global leader in providing innovative and sustainable nutritional solutions for the aquaculture industry. Skretting is also active on the fish feed market in West Africa.
Contact: Arjen Roem, arjen.roem@nutreco.com

Holland Aqua (www.hollandaqua.nl).
Holland Aqua offers consultancy and project management in the fields of aquaculture, air and water treatment.
Contact: Frans Aartsen, frans@hollandaqua.nl

Q-Point (www.q-point-bv.nl)
Q-Point is an advisory company, specialized in food safety, traceability, and integrated quality management and value chain management.
Contact: Victor Volkers, v.volkers@q-point-bv.nl

VIQON Water Solutions (www.viqon.com)
VIQON Water Solutions is specialised in consultancy in aquaculture with over a decade of experience.
Contact: Victor Bierbooms, victor@viqon.com

Sustainable Aquaculture Solutions (SAS) (www.sasnet.nl)
SAS is a consultancy company that enables more sustainable operations through improving quality and productivity, improving market access, reducing risk, and preparing and verifying compliance to sustainability standards.
Contact: Karin van de Braak, karin@sasnet.nl

Fishion (www.fishion.nl)
Fishion is a chain of cooperating entrepreneurs who ensure the production of sustainably farmed fish selling the product in the European food market. The main purpose of Fishion is to reduce the distance between producer and consumer through an efficient and fully transparent chain. Fishion represents an environmentally friendly product; fresh, healthy, sustainable and with minimal food miles. Fishion answers the growing demands of the modern consumer for sustainable and fresh fish.
Contact: Jan van Rijsingen, j.vanrijsingen@vanrijsingen.com

Hesy (www.hesy.com)
Hesy is an engineering company developing turn-key fish farming project.
Contact: Julian de Bondt, info@hesy.com

Dutch companies interested to invest in Ghanaian aquaculture

Van Der Zwan (www.wvanderzwan.nl)
Van Der Zwan is one of the leading fisheries companies in the Netherlands having a strong interest to develop fish farming.
Contact: Gerard Zwijnenburg, g.zwijnenburg@wvanderzwan.nl

De Heus (www.deheus.com)

De Heus Animal Nutrition is a leading international company animal feed industry. De Heus focusses on feed for cattle, pigs, poultry, and fish.
Contact: Rinus Donkers, rdonkers@deheus.com

Cornelis Vrolijk/Primstar (www.primstar.nl)
Cornelis Vrolijk/Primstar is a major fishing company of fish and shrimp and has shrimp farming operations in Ecuador and Nigeria.
Contact: Jacco Numan, jnuman@primstar.nl

References

African Economic Outlook (2014a). Country note Ghana.
http://www.africaneconomicoutlook.org/en/countries/west-africa/ghana/
Accessed on 26 March 2015

African Economic Outlook (2014b). Ghana 2014.
http://www.africaneconomicoutlook.org/fileadmin/uploads/aeo/2014/PDF/CN_Long_EN/Ghana_ENG.pdf
Accessed on 26 March 2015

Aggrey-Fynn, E. (2001). The contribution of the fisheries sector to Ghana's economy. A paper prepared on behalf of the FAO as an input into the Sustainable Fisheries Livelihoods Study. April 2001.
Ministry of Food and Agriculture.

Ahmed, N. (2013). On-farm feed management practices for Nile tilapia *(Oreochromis niloticus)* in Ghana. *In* M.R. Hasan and M.B. New, eds. *On-farm feeding and feed management in aquaculture.* FAO Fisheries and Aquaculture Technical Paper No. 583. Rome, FAO. pp. 191–211.

Antwi-Asare, T.O. & E. N. Abbey (2011). Fishery Value Chain Analysis Ghana.
http://www.fao.org/fileadmin/user_upload/fisheries/docs/Ghana_edited.doc
Accessed on 26 March 2015

Asmah R. (2008). Development potential and financial viability of fish farming in Ghana. PhD Thesis.

Atta-Mills J., Alder J. and Sumaila U.R. (2004). The decline of a regional fishing nation: The case of Ghana and West Africa.

Béné, C. (2007). Diagnostic study of the Volta Basin fisheries. Part 1 Overview of the Volta Basin fisheries resources. WorldFish. 31 pages.
http://pubs.iclarm.net/resource_centre/WF_2568.pdf
Accessed on 26 March 2015

CSIR-WRI (2013). Annual report 2013. 126 pages.

Embassy of the Kingdom of The Netherlands Accra (2014). Multi-Annual Strategic Plan 2014-2017 Ghana. 24 pages.

FAO (2004). Fishery country profile of Ghana.
ftp://ftp.fao.org/Fi/DOCUMENT/fcp/en/FI_CP_GH.pdf
Accessed on 26 March 2015

Globefish (2014). Tilapia - September 2014.
http://www.globefish.org/tilapia-september-2014.html

Accessed on 26 March 2015

Hamenoo, E. (2011). The role of the market in the development of aquaculture in Ghana. University of Tromso. Norwegian College of Fisheries Science. Master's Degree Thesis in International Fisheries Management. 64 pages.

Kassam, L. (2014). Aquaculture and food security, poverty alleviation and nutrition in Ghana: Case study prepared for the aquaculture for food security, poverty alleviation and nutrition project. WorldFish, Penang, Malaysia. Project Report: 2014-48.

Kaunda, K.W., Abban, E.K. and Peacock, N. (2010). Aquaculture in Ghana: Its potential to be a significant contributor to national fish supplies. Unpublished manuscript.

Koranteng K. A., Bortey A. and Yeboah D.A. (2006). The State of the World Fisheries from a Fishworker Perspective: The Ghanaian situation. 88 pages.

M&E/FC/MOFA (2010). 2009 Fisheries Commission Annual Report.

M&E/FC/MOFA (2012). 2011 Fisheries Commission Annual Report.

MOFA (2003). Fisheries management Plan for the Lake Volta. Accra, Ghana: Ministry of Food and Aquaculture, 75 pages.

MOFA (2012). Ghana National Aquaculture Development Plan (GNADP). Fisheries Commission. Ministry of Food and Agriculture. 78 pages.

MOFAD (2011). 2010 Annual Report. Accra, Ghana: Ministry of Fisheries and Aquaculture Development.

MOFAD (2013). 2012 Annual report. Accra, Ghana: Ministry of Fisheries and Aquaculture Development.

MOFAD (2014). 2013 Annual report. Ministry of Fisheries and Aquaculture Development.

Raanan (2015). Distributors.
http://www.raananfishfeed-wa.com/index.php/en/distributors
Accessed on 26 March 2015

Rurangwa E. (2014). Safeway College of Technology. Department of Aquaculture. Mission report of a quick assessment of needs. Imares report C112.4.
Under Current News (2014). Ghana's president outlines plans to increase fish farming.
http://www.undercurrentnews.com/2014/06/12/ghanas-president-outlines-plans-to-increase-fish-farming
Accessed on 26 March 2015

Justification

Rapport C021/15
Project Number: 4304107401

The scientific quality of this report has been peer reviewed by a colleague scientist and the head of the department of IMARES.

Approved: Henk van der Mheen
Senior Researcher

Signature:

Date: 27 March 2015

Approved: Robert Trouwborst
Head of Departments Aquaculture and Delta

Signature:

Date: 27 March 2015

Quality assurance

IMARES utilises an ISO 9001:2008 certified quality management system (certificate number: 124296-2012-AQ-NLD-RvA). This certificate is valid until 15 December 2015. The organisation has been certified since 27 February 2001. The certification was issued by DNV Certification B.V. Furthermore, the chemical laboratory of the Fish Division has NEN-EN-ISO/IEC 17025:2005 accreditation for test laboratories with number L097. This accreditation is valid until 1th of April 2017 and was first issued on 27 March 1997. Accreditation was granted by the Council for Accreditation.