On-farm feed management practices for Nile tilapia *(Oreochromis niloticus)* in Ghana

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ABSTRACT

This paper records the results of a study investigating on-farm feed management practices for the Nile tilapia (*Oreochromis niloticus*) aquaculture in Ghana. On-farm feed management practices were assessed at some randomly selected locations, examining various aspects of feed use in some earthen fishpond and fish cage farms. Earthen fishpond farms are widely scattered throughout the country whilst fish cage farms are concentrated on the Volta Lake. Fish production from aquaculture was 5 594 tonnes in 2008, which is only about 1.5 percent of domestic fish production. Fish farming is thus an emerging industry in Ghana. Nile tilapia accounts for over eighty percent of aquaculture production. Three types of feeds are in use; farm-made, locally produced and imported commercial feeds. Fish feed production and use have not been managed in earthen fish pond farms in a way that ensures maximum returns for farmers. Fish cage farmers were found to depend mostly on imported commercial feeds. Farm-made feeds for Nile tilapia were coarse, crumbly, powdery and sinking. Imported feeds were in pellet form, smooth and mostly floating. Areas into which research should be directed and the need for regulations to ensure the certification of fish feeds (both imported and locally produced) are suggested. The importance of proper storage of feeds was highlighted. Major knowledge gaps exist amongst the earthen fishpond farmers in feed formulation, preparation, use and management.

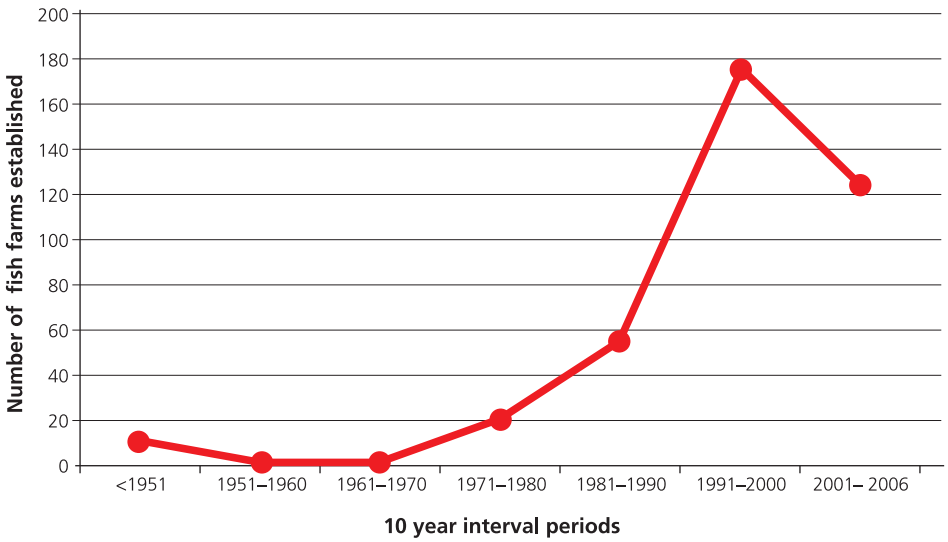
1. BACKGROUND

1.1 Introduction

The global farmed production of tilapia in 2008 was 2.8 million tonnes, valued at around US$4.0 billion (FAO, 2012). The most commonly cultured species in Africa is the Nile tilapia (*Oreochromis niloticus*) (Balarin, 1988). Aquaculture has been practiced in Ghana since 1958 (Abban *et al.,* 2009) when it was initiated as a component of a culture-based fisheries development programme. The programme involved the production of tilapia fingerlings in earthen fishponds to stock small reservoirs constructed in villages. During this period the pond farming of Nile tilapia (*Oreochromis niloticus*) was initiated in northern Ghana. In the initial years production remained low; however it subsequently spread to the rest of the country (Prein and Ofori, 1996). The growth of the sector (number of ponds constructed for this purpose) was greatest during 1980–2000 (Figure 1),

a period when it was promoted by the National Fisheries Department. During that period, several agricultural by-products (including guinea corn and maize chaff) were used as aquafeeds. At the same time organic manures, such as livestock droppings, were applied to stimulate natural production in the ponds. The sector has subsequently diversified, and became based on pond, pen, cage, and hatchery technologies (Prein and Ofori, 1996).

FIGURE 1
The number of aquaculture ponds in Ghana



Note: The increase in the number of fishponds constructed in Ghana can be considered as an index of the growth of the tilapia farming sector in Ghana.
Source: Asmah (2008).

Small-scale earthen fishponds are distributed throughout the country and account for 98 percent of the fish farms (Asmah, 2008). To date, irrigation sites have been favoured for development, and farming operations are currently concentrated in those areas. Alternatively, farms comprise small aggregations of earthen ponds that have been constructed by individual farmers. Fish pens and cages are primarily located in the Volta Lake (Asmah, 2008). This author estimated that over 96 percent of all the fish farms are subsistence farms, about three percent are small-scale commercial farms, and less than one percent are medium to large scale commercial farms.

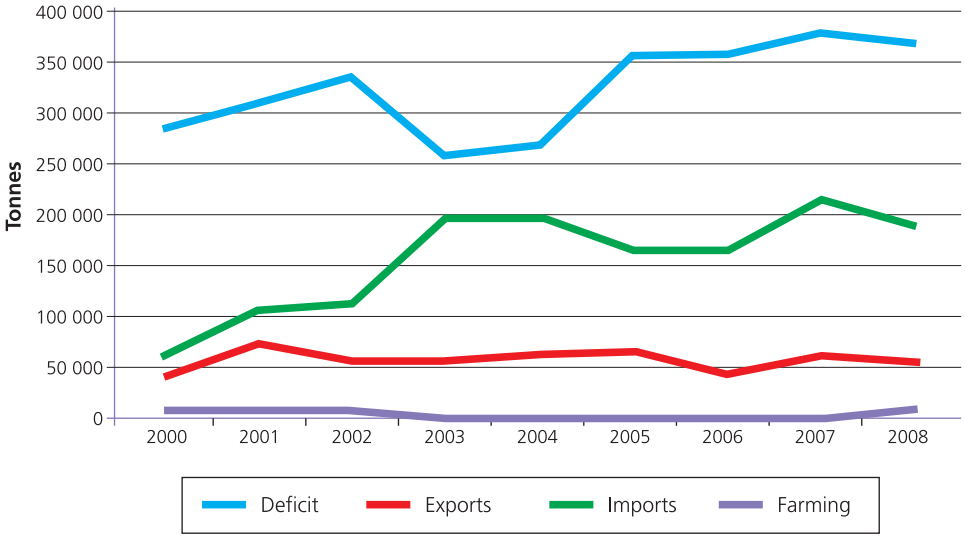
1.2 National farmed fish production

The largest commercial fish farms are cage farms (DoF, 2009). Sixty-eight percent of commercial fish production is derived from cage farms, twelve percent from earthen ponds, nineteen percent from small reservoirs (culture-based) and one percent from fish pens. In 2009, two commercial fish cage farms produced approximately 1 000 and 3 500 tonnes of tilapia respectively (DoF, 2009). Nile tilapia accounts for over 80 percent of national commercial fish farming production. The rest primarily comprises the African sharptooth catfish (*Clarias gariepinus*) and other species, including the African arowana (*Heterotis niloticus)* and the catfish *Heterobranchus* spp. (FAO, 2010).

According to FAO (2012) domestic production (from both capture fisheries and aquaculture) in Ghana was 365 425 tonnes in 2008. Of this, aquaculture accounted for about 1.5 percent (5 594 tonnes). At that time, the Directorate of Fisheries (DoF, 2008) estimated national fish requirements to be 931 198 tonnes and stated that total fish supply in 2008 was 566 513 tonnes (including imports) and there was a deficit of 364 685 tonnes, equating to 39 percent of the national fish requirement. Fisheries

contribute three percent to the total gross domestic product (GDP) of Ghana, and account for five percent of agricultural GDP. The national supply of fish is primarily from marine capture fisheries and the freshwater fishery in Lake Volta; these account for approximately 99 percent of fish production. To date, the contribution of aquaculture to total GDP has not been determined; however, it is evident that it is extremely small when compared to fisheries. In addition, fish are imported to make up for part of the shortfall in the national fish supplies. Despite the shortfall, some fish is still exported (Figure 2). Over the past decade, production from capture fisheries has not increased appreciably; however, the deficit in national fish production has shown a significant increase. The Ministry of Food and Agriculture has developed a policy calling for 60 percent of the national animal protein supply to be sourced from fish (MoFA, 2010).

FIGURE 2
National deficit in fish supply (tonnes) compared with exports, imports and production through aquaculture (2000–2008)



Source: DoF (2008).

1.3 Sector constraints and the potential to develop fishmeal replacement diets

Several challenges beset the industry. These challenges include land acquisition, seed and feed production and supply, credit availability and technology transfer (Abban *et al.*, 2006). Efforts to improve the growth rates of Nile tilapia, improvements to broodstock and seed production, and aquafeed and cage culture trials are in progress at the Water Research Institute of Ghana. An on-going study is aimed at developing models for allocating water space for cage culture on Lake Volta. Fish farming has been adopted by the DoF as one a means of increasing fish production and offsetting the deficit in supply (DoF, 2008). As a result, tilapia culture has gained prominence in Ghana. In 2008, 5 100 tonnes of Nile tilapia was produced, equating to 91 percent of total national aquaculture production recorded by FAO (2012). Feed generally accounts for between 30–60 percent of production costs (De Silva and Anderson, 1995), and in the past the unavailability of aquafeeds has limited production. Fishmeal or animal protein supplements are the main source of protein used in aquafeed formulations (Tacon, Metian & Hasan, 2009). A baseline survey of fish farmers in Ghana in 2003–2004 showed that a very wide range of materials were used, including agricultural by-products such as maize bran and wheat bran (Table 1) that are generally poor quality ingredients. Improving the nutrient availability in some of the available feed ingredients requires further processing (De Silva and Anderson, 1995).

TABLE 1

Fish feed inputs used by fish farmers in rural Ghana

Feed ingredients	Number of farmers per district				
	Upper Denkyira	Wassa West	Sefwi	Ashanti	Total
Animal origin					
Anchovy				2	**2**
Fresh blood/blood meal	1			3	**4**
Chicken offal				3	**3**
Fishmeal		1		2	**3**
Fish rejects			2		**2**
Intestines (unspecified)				1	**1**
Maggots				1	**1**
Poultry offal				2	**2**
Termites	1		4		**5**
Plant origin					
Bean flour			3		**3**
Brewery waste				2	**2**
Cabbage leaves		1			**1**
Cassava			5	4	**9**
Cassava leaves			1	1	**2**
Cassava - boiled				1	**1**
Cassava - cooked			3	1	**4**
Chaff*			1		**1**
Coconut chaff		1			**1**
Cocoyam leaves		1	5	2	**8**
Corn chaff/bran			13	1	**14**
Corn flour/meal		1	3		**4**
Food crops (unspecified)			1		**1**
Fruit (unspecified)			2	1	**3**
Gari fruit			1		**1**
Groundnut husks/peels	3	5	2	36	**46**
Kenkey**				1	**1**
Leaves (unspecified)		1	20	1	**22**
Maize				1	**1**
Maize bran	6	4	6	11	**27**
Maize chaff			1		**1**
Maize flour			1		**1**
Maize grits				2	**2**
Milling wastes (unspecified)		1			**1**
Palm fruit			2		**2**
Palm kernel oil cake	1				**1**
Pawpaw leaves			4		**4**
Pawpaw fruit	1		2	2	**5**
Pito mash		3		1	**4**
Rice bran	12	1	44	23	**80**
Vegetables (unspecified)	1			1	**2**
Wheat bran		14	3	5	**22**
Miscellaneous					
Commercial feed		1			**1**
Farm waste		4			**4**
Feed – unspecified		13			**13**
Kitchen waste	5	7	3	6	**21**
Local house feed (unspecified)			2		**2**
Poultry feed				4	**4**
Total	**31**	**59**	**135**	**121**	**346**

Source: FAO (2005).

Notes: *Dry, scaly protective casings of the seeds of cereal grain, or similar fine, dry, scaly plant material, such as the scaly parts of flowers, or finely chopped straw; **Fermented maize meal traditionally prepared by boiling balls of mixed portions of fermented cooked maize meal and raw maize dough.

The high cost of fishmeal has prompted research into developing cost-effective fishmeal replacements as protein sources. In Ghana, the cost of imported fish feeds with a protein content of thirty percent is above US$1.0/kg[1]. A feed development programme undertaken by the Animal Research Institute (ARI) of the Council for Scientific and Industrial Research (CSIR) established the availability, distribution, and seasonality of various agro-industrial by-products (Nelson and Wallace, 1998). Agro-industrial by-products such as guinea corn chaff, groundnut husk and cake are available in the northern parts of the country, and maize chaff is available throughout the country. Tilapia production trials to test the efficacy of using agro-industrial by-products in feed formulations have been undertaken for a number of species (Attipoe, Nelson and Abban, 1998; Ofori and Asamoah, 1996). Ofori (1988) demonstrated that rice bran could be used as a single feed input for Nile perch (*Lates niloticus*) culture, and obtained a yield of 1 427 kg/ha/year. Other trials testing the potential to use plant protein sources in dietary formulations for the African sharptooth catfish (*Clarias gariepinus*) are ongoing. Despite the presence of an anti-nutritional factor – mimosine (Francis, Makkar and Becker, 2001), leucaena leaves (*Leucaena leucocephala*) have also shown potential as a fishmeal replacement (Amisah, Oteng and Ofori, 2009).

1.4 Common feedstuffs and manure

The most common feedstuffs used in rural Ghana include rice, maize and wheat bran, various leaves, vegetables (primarily cassava leaf), and a variety of other foodstuffs (FAO, 2005). The leaves that are available include cocoyam and cabbage leaves, while the fruits include pawpaw and avocado pears. These materials are used as single feed ingredients (Table 1). With respect to organic manures, cow dung, grass-cuttings and sheep, poultry, goat and swine manure are applied (FAO, 2005).

To date, integrated agriculture/aquaculture systems have not been developed in the country, and aquaculture is undertaken as a stand-alone activity, with few linkages to other farming enterprises (Prein and Ofori, 1996). However, FAO (2005) reported that the use of agro-industrial by-products, plant materials and animal wastes in aquaculture is extensive (Table 2). Despite this, pond production based on these materials is problematic as supplies are often intermittent; sufficient quantities of these materials are rarely available throughout the year (Ofori, 1988). In this regard, it is important to determine the on-farm management strategies that are used by farmers to resolve these supply issues.

TABLE 2
Fertilizer inputs used by fish farmers in rural Ghana

Type of fertilizers	Number of farmers per district				
	Upper Denkyira	Wassa West	Sefwi	Ashanti	Total
Inorganic fertilizers					
Inorganic fertilizer (unspecified)		2			**2**
Nitrogen, phosphorus and potassium (NPK)			2	1	**3**
Organic manure					
Cow dung			2	4	**6**
Goat manure			10		**10**
Grasscutter manure				1	**1**
Organic manure (unspecified)	9	39	1		**49**
Poultry manure			25	35	**60**
Sheep manure			12	3	**15**
Swine manure			4	6	**10**
Unspecified				2	**2**
Totals	**9**	**41**	**56**	**52**	**158**

Source: FAO (2005).

[1] See Table 8 of this document.

2. METHODOLOGY

A review of current feed use and feed manufacturing practices for *O. niloticus* production was conducted at randomly selected locations in eastern, central and western Ghana (Figure 3). A total of four cage farms were surveyed in the eastern region of Akosombo (Lee's farm, Sang-you), South Senchi Solidarity (Atimpoku near Akosombo) and the Dim fish farmers group, not far from Donkorkrom in Afram Plains district. A total of fourteen pond farmers were surveyed. A description of the pond facilities and the respective levels of production is provided in Table 3. The fish cage farms comprise small production units. No large scale commercial fish cage farms were included in the analysis as they were unwilling to participate in the survey. The locations of the pond farms that were selected in the survey were Tarkwa, Terebe, Abosso, Achampong Krom, (all near Tarkwa) Tano-Odumase near Kumasi, Asutuare, Sunyani, Ashaiman and Winneba.

FIGURE 3
Map of Ghana showing the location of farms selected for the study

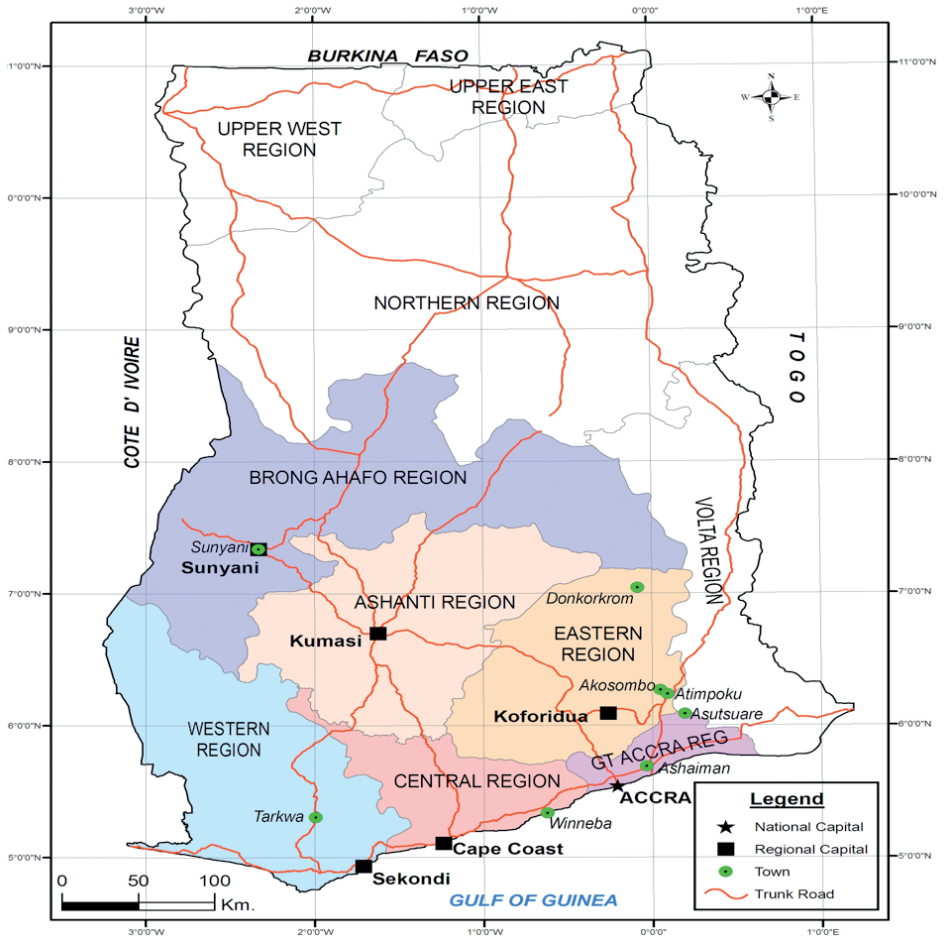


TABLE 3

Fish farm location, facilities and estimated production (2009)

Name of farm	Location	Type of culture system	Rearing facilities	Estimated production
Ashaiman	Ashaiman	Earthen ponds and concrete tanks	5 earthen ponds (12 m x 13 m each) and 12 concrete tanks (10 m x 5 m each). Tilapia fingerling production farm	1 140 000 fingerlings of tilapia produced
Achampong	Achampongkrom (Tarkwa)	Earthen pond	1 pond (0.05 ha)	0.075 tonnes
Dotsu	Adieyie (Tarkwa)	Earthen pond	1 pond (0.05 ha)	0.06 tonnes
Ansah	Winneba	Earthen pond and concrete tanks (new farm)	3 ponds (9.2 m x 10 m each) and 6 concrete tanks (5 m x 10 m)	20 000 fingerlings
Akrofi	Abosso (Tarkwa)	Earthen pond	3 ponds (0.1 ha each) and 6 small concrete tanks for fingerling production	0.25 tonnes
Vikwam	Abosoo (Tarkwa)	Earthen pond	3 ponds (0.2 ha each), 3 ponds (0.05 ha each), 7 ponds (0.01 ha each)	0.5 tonnes
Karbo	Sunyani	Earthen pond	2 (0.1 ha), 1 pond (0.05 ha)	0.37 tonnes
Takyi grow out and fingerling production farm	Sunyani	Earthen pond	2 ponds (0.1 ha each), 1 pond (0.2 ha) and seven fingerling production ponds 6 sized 100 m^2 and 1 of 200 m^2	0.23 tonnes
Nkrumah	Sunyani	Earthen pond	1 pond (0.07 ha), 1 pond (0.06 ha)	0.25 tonnes
Tonku and	Sunyani	Earthen pond	1 pond (0.032 ha), 1 pond (0.03 ha). Also fingerling production ponds of 270 m^2, 60 m^2 and 50 m^2	0.008 tonnes
PAC	Kona-Odumase	Earthen pond	2 ponds (0.11 ha each), 19 ponds (0.036 ha each). Fingerling production facilities as follows, concrete: 4 (50 m^2), 2 (48 m^2 and 18 m^2), 10 (10 m^2); fibreglass: 5 (4 m^2), 10 (2 m^2), 10 (0.5 m^2)	Only 400 000 fingerlings of tilapia produced due to rehabilitation works
Faith Heroes	Asutuare	Earthen pond	3 ponds (1 ha, 0.29 ha, 0.23 ha)	3 tonnes
Ansong	Asutuare	Earthen pond	3 ponds (0.36 ha each), 2 ponds (0.09 ha each)	0.15 tonnes
Annan	Winneba	Earthen ponds under rehabilitation	19 ponds of various sizes totalling 1.23 ha	0.6 tonnes
Lee's farm	Akosombo	Fish cage	50 fish cages (6 x 5 x 5 m^3 each)	85 tonnes
Sang-you farm	Akosombo	Fish cage	60 fish cages (6 x 5 x 5 m^3 each)	102 tonnes
South Senchi Solidarity group	Senchi	Fish cage	4 cages (5 x 4 x 4 m^3 each)	2 tonnes
Dim fish farmers group	Dim (Afram Plains)	Fish cage	2 cages (5 x 4 x 4 m^3 each)	0.8 tonnes

Source: Field survey (2010).

3. RESULTS

3.1 Review of current feed use and feed management practices

3.1.1 Type of feeds

A range of feed types were recorded during the farm survey; these included commercially produced feeds, farm-made feeds, and supplemental feeds (agricultural by-products). Commercially produced feeds are currently imported from nine countries (Table 4), and two are being produced locally. Various sizes of floating pelleted feeds are imported for grow-out culture, and powdered feeds are imported for fry production. Feed is delivered in air-tight bags ranging in weight from 25.0 to 45.2 kg/bag. The proximate composition of the feed is provided for some but not all of the imported feeds. The local commercially prepared feeds are placed in feed bags that are not airtight and are supplied in 1.0 kg and 25.0 kg bags. Pelletizing is undertaken by hand, and thus pellet sizes are not uniform and the feeds tend to have a high percentage of fines. Farm-made feeds are stored in bags or jute sacs that are not airtight. To prevent the feeds from deteriorating and becoming mouldy, the feeds are made in small batches and are not stored for long periods of time.

3.1.2 Commercial feeds

Commercially produced feeds are imported into the country from Israel, the Netherlands, Egypt, Singapore, Indonesia, Denmark, Brazil, China and Viet Nam (Table 4). The imported feeds include fry, broodstock and grower formulations**.** Starter feeds have been imported from Denmark, Brazil and Israel. Fish feeds are not imported by the government. All the imports are made by the private sector. All the imported grower feeds are extruded floating feeds. Powdered fry feeds are also imported for fingerlings. Pellet sizes range from 0.3 mm to 6 mm. Two locally produced feeds are also available, with the trade names Aqua feeds and Aqua Engine. In recent years, commercial fish feed imports into Ghana have been increasing (Table 5).

TABLE 4
Country of origin of fish feed pellets available on the Ghanaian market

Country of origin	Feed name	Feed pellet size (mm)
Singapore	Inter quality (premium quality) 7002 feed	2, 4, 6
Indonesia	P. T. Matahari Sakti	4, 6
Viet Nam	Inter Quality Premium (Vasafeed Co. Ltd)	2, 4
Israel	Ranaan feed	2.5, 4.5
Denmark	Aller Aqua feed	0.3, 0.5, 0.7, 1, 1.5, 1.8, 2
Egypt	-	1, 2, 4, 6
Brazil	Pira Alevino feed, Proaqua (Nuton Alimentos Ltd.)	2, 4, 6
China	-	-
Netherlands	Coppens	3, 4.5

Source: Fisheries Commission (2010).

TABLE 5
Tilapia aquafeed imports (2006–2009)

Year	2006	2007	2008	2009
Quantity (tonnes)	21.5	235.0	126.1	518.7

Source: Fisheries Commission (2010).

3.1.3 Nutrient composition of commercial feeds

The proximate composition of the imported feeds that are available in Ghana is presented in Table 6. The protein contents ranged between 30 and 40 percent, and the lipid between 4.5–10 percent. The moisture content of the feeds ranged between 5.1–11 percent although most of the feed manufacturers did not provide the moisture content. It was evident that the labelling of some of the feeds was not sufficient to provide the farmers with the necessary information required to assess the suitability of the feeds. For example, the Aqua Engines feed only provided information pertaining to the protein content of the feed and provided no additional proximate composition data.

TABLE 6

Proximate composition and other nutrients in some of the commercial fish feeds in Ghana

Nutrient	Inter Quality Premium quality	Inter Aqua Feed	Coppens (Type 1)	Coppens (Type 2)	Ranaan (Type 1)	Ranaan (Type 2)	Aqua Engines
Moisture (%)	√	11	5.1	-	-	-	-
Crude protein (%)	30	30	40	34	30	30	32
Crude lipid (%)	4.5–5.0	5	10	10	4.5	4.5	√
Crude fibre (%)	6	6	-	3	√	5.5	√
Ash (%)	16	16	6.7	6	√	6.9	√
Premix (%)	-	-	-	-	-	-	√
Common salt (%)	2.5	2.5	0.1	0.2	-	-	-
Lysine (%)	-	-	-	-	1.6	1.6	√
Methionine (%)	-	-	-	-	1.0	-	√
Copper (mg/kg)	-	-	-	-	√	3	-
Vitamin A (IU/kg)	-	-	1 500	-	-	4 500	-
Vitamin D^3 (IU/kg)	-	-	-	-	√	1 050	-
Vitamin C (mg/kg)	-	-	150	150	√	90	-
Vitamin E (mg/kg)	-	-	200	200	√	120	-
Phosphorus (%)	-	-	0.9	0.7	-	-	√
Calcium (%)	-	-	0.8	1.0	-	-	√
Preservatives	-	-	-	E 280	-	-	-
Antioxidants	-	-	-	E 324, E 321	-	-	-

Source: Feed labels of commercial feeds available in Ghana.
Notes: √ = presence of the component; - = component not indicated.

The inadequate feed composition data provided to the farmers is largely due to the fact that the Fisheries Commission requires feed importers only to declare the tonnage of feed imported; providing proximate compositional data is not a statutory requirement.

3.1.4 Ingredients used in commercial feeds

Fishmeal and soybean are the primary protein sources used in all the imported feeds (Table 7). Other ingredients listed include rice bran, cereal meals, fish oil, and vitamin and mineral premixes. The feed ingredients used in the locally produced feeds include fishmeal, soybean, wheat bran, rice bran and vitamin and mineral premixes. The fishmeal used in these formulations is imported. The locally manufactured feeds are sinking feeds.

TABLE 7
The ingredient composition of selected commercial feeds

	Fishmeal	Soybean	Fish oil	Palm oil	Rice bran	Maize	Wheat	Premix	Wheat bran
Inter Quality Premium quality 7002 feed (imported)	√	√	√		√			√	
Ranaan feed (imported)	√	√				√			√
Aqua Engine (local)	√	√		√				√	√
Aqua feed (local)	√	√	√		√			√	
Coppens (imported)	√	√	√	√			√	√	

Source: Field survey (2010).

Note: √ = presence of the ingredient in feed.

3.1.5 Feed prices

Imported aquafeeds are exempt from import duties and value added tax (VAT); this is due to the Government policy of maintaining low prices for agricultural inputs and stimulating sectoral development. Retail feed prices are presented in Table 8. The price of grow-out feeds ranged between US$0.72/kg for a locally produced feed containing 32 percent protein to US$1.60/kg for an imported feed containing 30 percent protein. Starter feeds for fry and fingerlings were imported by one supplier. The fry and fingerling feeds are more expensive and contained a higher protein content than the grow-out feeds. The fry feed cost 2.59 US$/kg (48 percent protein), and the fingerling formulation cost US$1.87/kg (40 percent protein).

TABLE 8
The price of grow-out and starter feeds

Feed	Price		Protein (%)	Pellet size (mm)	Location of retailer
	GHS/kg	US$/kg			
Inter Quality Premium quality 7002 feed	35/25*	1.01	30	2, 4	Takoradi
Ranaan feed	36/20	1.30	30	2, 4.5	Accra Sunyani
Ranaan feed	45.2/20	1.60	30	4.5	Tarkwa
Ranaan feed (starter - fry)	72/20	2.59	48	0.3–0.6; 0.6–0.9	Ashaiman
Ranaan feed (starter - fingerling)	52/20	1.87	40	2	Ashaiman
Aqua Engines**	1.0	0.72	32	2, 4	Accra
Aqua feed**	25/25	0.72	-	-	Accra
Inter Aqua Feed	35/25	1.01	30–35	4.5	Accra
Inter Aqua Feed	39/25	1.15	-	-	Accra
Coppens	37.8/15	1.81	40	3, 4. 5, 6	Akuse

Source: Field survey (2010).

Notes: *35 GHS (Ghanaian Cedi) per 25 kg bag; Bank of Ghana exchange rate: US$1.00 = GHS 1.39 (19/5/2010);
** locally-produced feed.

3.1.6 Supplemental feeds

Supplementary feeds are either presented in the form of single ingredients, simple mixtures of powdered ingredients, or ingredients compounded into doughs or pellets. The farm-made feeds recorded in the present study were used as complete feeds; however, it was evident that they could not supply all the nutrient requirements of the fish. The farmers maintained their fish stocks on the feeds prepared on their own farms.

3.1.7 Fertilizers

Based on the results of the case study, the application of the pond fertilizers - both organic and inorganic - is poorly executed by the farmers, and their effect on water quality and fish production is poorly understood. The efficacy of their use is not monitored, and the farmers demonstrated that they were unable to estimate the level of primary productivity in their ponds.

Nine of the pond farms in the survey used organic manures (mainly chicken droppings, pig dung or cow dung and wood shaving mixture in occasional cases, Table 9). These manures were used at various application rates, and were applied to the pond bottoms prior to filling and during the production cycle. In one farm, approximately 25 kg of the semi-dry chicken manure and wood shaving mixture is placed in a polythene bag. Small holes are made in the bag, and it is placed in the corner of the pond, enabling the nutrients to leach into the pond. The wood shavings remain in the sac. The bag is left in the pond until the pond waters turn green. Some farmers applied both organic and inorganic fertilizers; these were applied during the culture period, not during pond preparation. The farmers exhibited a minimal understanding of the rationale behind their fertilization regimes, and only one farmer indicated that he fertilized his pond to increase primary productivity. A second farmer indicated that fertilizers increase fish production. The farmers added hydrated lime to their ponds at 0.35–3.5 tonne/ha/year (Table 9).

TABLE 9
Lime and organic manure application rates in selected farms

Farm name	Lime		Manure		
	Rate of application (tonnes/ha)	Price (US$/kg)	Rate of application (tonnes/ha/year)	Price (US$/kg)	Remarks
Ashaiman	0.35	0.29	No use reported	-	Green pond water
Achampong	1.0	0.5	2.0	Obtained free of charge	Green pond water
Dotsu	1.0	0.5	2.0	Obtained free of charge	Green pond water
Ansah	No use reported	-	No use reported	-	-
Akrofi	1.0	0.5	2.0	Obtained free of charge	Green pond water
Vikwam	1.0	0.5	2.0	Obtained free of charge	Green pond water
Karbo	No use reported	-	4.0	0.03	Green pond water
Takyi	No use reported	-	4.0	Obtained free of charge	Green pond water
Nkrumah	No use reported	-	4.0	0.03	Green pond water
Tonku	Wood ash; quantity not reported	-	50 birds/400 m^2 (i.e. 1 250 birds/ha)	Obtained free of charge	Green pond water
PAC	1.0	0.36	0.37	Obtained free of charge	Green pond water
Faith Heroes	3.5	0.29	1.1	0.14	Light green pond water
Annan	No use reported	-	No use reported	-	-

Source: Field survey (2010).

3.1.8 Farm-made feeds

Of the fourteen pond farms surveyed, only three depended solely on commercially manufactured aquafeeds. Six of the remaining farmers based their formulations on gross inclusion rates (weight), but did not take into consideration the nutritional qualities of the ingredients. The other five pond farmers in the survey did not apply fixed ratios of the ingredients that they used in their formulations. On some farms, buckets were used to measure the quantity of the ingredients used in the formulations, and the ratio of ingredients used in the feeds varied between production batches. Evidently, the formulations depended on the availability of finance to purchase feed ingredients - in particular fishmeal, which is the single most expensive feed ingredient. The cost of fishmeal imported from Brazil (64 percent protein) was US$1.43/kg. While some of the farm-made feeds are made into pellets using simple electric extruders (Figures 4 and 5), much of the feed is presented to the fish as wet doughs. In the rainy season, the feeds are presented to the fish as moist feeds because it is impossible to sun-dry them in the inclement weather. The prices of some raw materials available for use in farm-made feeds are provided in Table 10.

FIGURE 4
Electric fish feed pelletizer used to produce farm-made feeds

COURTESY OF E. DATUAH.

FIGURE 5
Pelletized farm-made feed being sun-dried on a plastic sheet

COURTESY OF E. DATUAH.

TABLE 10
Prices of local feed stuffs used as feed ingredients

Feed ingredient	Location	Price (US$/kg)
Wheat bran	Accra	0.16
Maize bran	Abosoo (Tarkwa)	0.40
Maize meal sweeping	Sunyani	0.07
Soybean	Sunyani	0.67
Groundnut peel	Tarkwa	1.99
Groundnut peel	Sunyani	0.12
Rice bran	Asutuare	0.07
Rice bran	Sunyani	0.07
Pito waste	Sunyani	0.12
Blood from abattoir	Sunyani	-
Poultry manure	Kona-Odumase	0.012

Source: Field survey (2010).
Notes: Ingredients come in various sized containers; prices have been converted to US$/kg.

The survey revealed that farm-made feeds using agricultural by-products and other feed ingredients were prepared using the following ingredients:

- Maize bran, wheat bran, ground whole soybean and fishmeal, plus starch as a binding agent.
- Maize bran, groundnut peel, fishmeal, plus starch as a binding agent (producing a 25 percent protein content diet).
- Maize bran, pito (Guinea corn chaff) waste, palm kernel chaff, groundnut husk and peel, fishmeal, plus starch as a binder (producing a 30 percent crude protein content diet).
- Groundnut peel and blood from a slaughter house, mixed with a commercial feed - 3 kg (groundnut peel and blood) were mixed with 2.25 kg of Ranaan feed.

The use of other plant based ingredients such as leaves, stems, fruits, flowers, stem and root tubers that have been previously been reported as suitable feed ingredients for farm-made feeds (FAO, 2005) was not reported in the present study.

All the commercial fish cage operators reported using commercially produced imported aquafeeds.

3.1.9 Pellet stability

All the farm-made feeds were crumbly and coarse to the touch when compared with imported manufactured feeds, which were more compact and stable. Even with the addition of a binder such as cassava starch, the farm-made feeds were poorly bound and quickly disintegrated when broadcast onto the surface of the water. Feed losses due to poor ingestion rates would likely be high using these poorly bound farm-made feeds.

3.2 Selection and choice of feeds

As manufactured aquafeeds are in short supply, farmers do not always have the opportunity to select the type of commercially produced feeds that they would like to use.

With regard to the preparation of farm-made feeds, the farmers indicated that they did not have access to information and knowledge that would enable them to prepare nutritionally balanced feeds. Of those feeds that were being prepared, it was evident that some would be unable to satisfy the nutritional requirements of the fish (Table 11). For example, one farmer produced feeds that comprised wheat bran and rice bran and no other ingredients. Only two farmers reported using mineral premixes in their formulations.

TABLE 11

Ingredients used in farm-made tilapia feeds

Farm	Fishmeal (%)	Soybean (%)	Blood from slaughter house	Groundnut peel	Maize bran	Wheat bran (%)	Rice bran	Pito waste	Palm kernel chaff	Premix (%)	Starch as binding agent
Ashaiman	√	44	-	-	-	8	-	-	-	0.05	-
Achampong	-	-	-	-	-	-	-	-	-	-	-
Dotsu	√	-	-	-	-	33.3	-	-	-	-	-
Ansah	-	-	-	-	-	-	-	-	-	-	-
Akrofi	√	-	-	√	√	√	-	√	-	-	-
Vikwam	√	-	-	√	√	√	-	-	-	-	-
Karbo	25	√	-	-	√	√	-	-	-	-	√
Takyi	30	-	-	√	√	-	-	-	-	-	√
Nkrumah	√	-	-	√	-	-	-	√	√	-	√
Tonku	-	-	√	√	-	-	-	-	-	-	-
PAC	√	-	-	√	-	√	√	-	-	-	-
Faith Heroes	-	-	-	-	-	√	√	-	-	-	-
Ansong	-	-	-	-	-	-	-	-	-	-	-
Annan	33.3	33.3	-	-	-	16.7	-	-	-	-	-

Source: Field survey (2010).

Note: √ = presence of the component .

3.3 Feed procurement, transportation and storage

Feed importation was managed solely by fish feed importers, who determined the feed price that they charge the farmers. Fish feed and other imported fish farm inputs are exempted from customs duties and VAT. With a letter of recommendation from the Ministry of Food and Agriculture to the Commissioner for the Customs, Excise and Preventive Service, the importer is allowed to clear imports without duty payments. It was noted that feed prices throughout the country were not related to the distance from the port of entry. This was attributed to the fact that the feed was delivered from different sources, was packed in different weight sizes, and had different formulations and pellet sizes (Table 8).

Imported feeds are transported in metallic containers from the ports to warehouses in the capital, Accra. Feed dealers either distribute the feed to locations closer to the farmers or, if larger quantities were required, transported the feed directly to the farmers.

In the central feed warehouses, the feeds are stored on pallets and are protected from spoilage (e.g. rodents). In contrast, on the farms the aquafeeds are not kept under optimal storage conditions. Feeds are often stored on the floor, and in some cases pallets are not used. This allows rodents to access the feed. In one case, the feed was kept in the open and covered with a tarpaulin at night. In inclement weather the feed would inevitably get wet and mouldy.

3.4 Review of existing feeding strategies

Both commercially produced and farm-made feeds were used by the farmers, either alone, in alternation, or in combination.

3.4.1 Feeding frequency

Fish were fed between two and four times a day (Tables 12 and 13). The daily ration was divided according to the feeding schedule shown.

3.4.2 Feeding rates

It was difficult to substantiate claims regarding the feed management practices. While mortalities occurred during the production cycle, farmers did not keep appropriate records. Pond farmers were generally advised by the Fisheries Officers to administer feed at rates equivalent to five percent of body weight of fish per day. However, many farmers fed at a constant rate throughout the production cycle, and were unaware that such practices were wasteful and would lead to low feed efficiencies. Knowledge regarding feeding tables is only becoming wide spread with the advent of commercial fish farming and the provision of feeding tables by some commercial feed producers. Feeding tables were only provided by one feed importer, and thus farmers in general were unable to accurately calculate feed rations.

3.4.3 Feed type

The commercial grow-out feeds were available in various pellet sizes, and in a powdered form for fry. The local farm-made feeds were either prepared as powders or pelletized using locally made pelletizers. The farm-made pellets were of uneven sizes and were broken into smaller pieces by breaking the extruded strands by hand. In order to feed juvenile fish or fingerlings, some farmers physically broke up the large commercially manufactured pellets into smaller pellets or powders. None of the farmers owned an extruder, and thus they were unable to make floating feed.

TABLE 12

Feed type and feeding frequency of feeds used in grow-out systems in surveyed farms

Farm	Type of feed	Commercial feed brand	Method of application	Feeding frequency (times/day)
Ashaiman	Commercial and farm-made feed	Ranaan feed	Broadcasting commercial and farm-made pellets	2 for brooders and 4 for fingerlings
Achampong	Commercial feed	Inter Quality Premium (Vasafeed Co. Ltd)	Broadcasting commercial pellets	2
Dotsu	Commercial and farm-made feed	Inter Quality Premium (Vasafeed Co. Ltd)	Broadcasting commercial pellets and farm-made dry powder	3
Ansah	Commercial feed	Inter Quality Premium (Vasafeed Co. Ltd)	Broadcasting commercial pellets	2
Akrofi	Commercial and farm-made feed	Ranaan feed	Broadcasting commercial and farm-made pellets	3 (4 for fingerlings)
Vikwam	Commercial and farm-made feed	Ranaan feed	Broadcasting commercial and farm-made pellets	2
Karbo	Commercial and farm-made feed	Ranaan feed	Broadcasting commercial and farm-made pellets	2
Takyi	Commercial and farm-made feed	Ranaan feed	Broadcasting commercial and farm-made pellets	2
Nkrumah	Commercial and farm-made feed	Ranaan feed	Broadcasting commercial and farm-made pellets	2
Tonku	Farm-made feed	-	Broadcasting farm-made pellets	2
PAC	Commercial and farm-made feed	Ranaan feed	Broadcasting commercial and farm-made pellets	3
Faith Heroes	Farm-made feed	-	Broadcasting farm-made pellets	2
Ansong	Commercial feed	Inter Aqua feed	Broadcasting commercial pellets	2
Annan	Commercial and farm-made feed	Yes (feed brand not reported)	Broadcasting commercial pellets and farm-made dry powder	4 (5 for fingerlings)

Source: Field survey (2010).

TABLE 13

Method of application of feeds and feeding frequency for tilapia fry on surveyed farms

Farm	Type of feed	Commercial feed	Ingredients in farm-made feed	Method of application	Feeding frequency (times/day)
Ashaiman	Commercial and farm-made feed	Ranaan	Wheat bran, fishmeal, soybean cake, vitamin premix	Broadcasting dry powder over the water	4
Annan	Commercial and farm-made feed	Inter Quality Premium	Wheat/rice bran fishmeal, soybean meal, premix	Broadcasting dry powder over the water	4
Vikwam	Commercial feed	Ranaan	Farm-made feed feeds not used	Broadcasting dry powder over the water	2
Akrofi	Commercial feed	Ranaan	Farm-made feed feeds not used	Broadcasting dry powder over the water	4

Source: Field survey (2010).

3.4.4 Feed additives

Some of the imported commercially prepared fish feeds contained additives (premixes), the composition of which was clearly indicated on the packaging material. The Ranaan feed listed the following as the additives in its feed: lysine, methionine, copper, vitamin A, vitamin D3, vitamin C and vitamin E. The rest of the feeds did not indicate the type of additives used in the feed.

3.4.5 Feeding methods, efficacy and possible improvements

Typically, the feeds were broadcast over the pond surface (Tables 12 and 13) and no attempt was made to concentrate the feed in a particular area of the pond. In only one case was a strategy adopted to minimize losses of sinking feed. In this case, the feed was broadcast in small quantities so that the fish could consume it before it sank.

On one farm, the farmer mixed an imported feed with a farm-made feed at a ratio of 1:1. On another, imported feeds were fed to the fish during the first two months of production; thereafter local farm-made feeds were used to rear the fish to market size. Where small feed pellets were not available, the farmers broke up the imported commercial pellets into smaller sizes for the fish to consume. One farmer reported alternating the farm-made feeds with the imported feeds. In all cases, there were no documented advantages to the feeding strategies adopted; however the farmers indicated that they were able to feed the fish for a long period of time with very few financial resources at their disposal.

3.4.6 Feed monitoring

Farmers monitored the growth of the fish visually, and did not record growth rates. Those farmers that used imported commercial feeds attributed their growth rates to the quality of feed and the fish seed. It was widely accepted that the imported feeds were more efficacious than the farm-made feeds.

4. DISCUSSION

Tilapia production in Ghana is increasing, and over 80 percent of the production is derived from cage farms where imported commercially complete feeds are used. All the imported feeds are extruded floating tilapia feeds. The imported feeds are relatively expensive and this was cited by some of the farmers as one of the reasons why they resorted to the use of farm-made feeds. Apart from fishmeal, the feed ingredients used in preparing farm-made feeds are not imported. Fishmeal and soybean comprise the primary protein sources that are used in the production of farm-made feeds. Blood meal from slaughterhouses was used in only one of the 14 farms surveyed, and this was as a result of its close proximity to a slaughterhouse. Wheat, maize and rice bran were the primary carbohydrate sources that were used in farm-made feeds. The nutrient composition of the ingredient sources was not a consideration in terms of formulation. Wheat bran was widely used because it is widely available throughout the country. Cassava is also widely available but at present it is not used in farm-made feeds as it has not been introduced to the farmers as a potential feed ingredient.

The farmers do not have extruders, and only three of the farms surveyed used locally-made mincers as pelletizers. To prepare the feed, the feed mixture is moistened and extruded through the mincer. The carbohydrate component of the feed meal provides the starch that acts as a binder. The feed is sun-dried, and the extruded strands are broken into smaller pieces that can be consumed by the fish. The pellets tend to be coarse and are not of uniform size.

Some of the farm-made feed is wasted during the feeding process when inappropriate pellet sizes are used and they are too small or too large to be ingested by the fish. Alternatively, feeds that have a large percentage of fines result in poor ingestion rates and feed is wasted as the fines disperse in the water column. At the Ashiaman farm,

the manager estimated that 10 percent of the feed was reduced to powder during the manual hand pelletizing process. The feed that sinks accumulates at the bottom of the pond, reducing water quality. The risk of water quality deterioration and an associated reduction in fish growth is ameliorated when the accumulation of organic matter is minimized (Ofori, 2001), or when the fish are cultured in cages where there is adequate water flow. The use of manures and chemical fertilizers in combination with formulated feeds has been well documented (Shroeder, 1973; Boyd, 1992). However, knowledge concerning the use of on-farm wastes for fish production in Ghana is limited (Owusu-Frimpong, 1989). As a result, farmers use both organic and inorganic fertilizers in a haphazard manner that is not related to water quality parameters. In addition, farmers do not measure the natural productivity in their ponds, and thus they are unable to modify their fertilizer use appropriately.

Local feedstuffs are cheap but are not widely available in sufficient quantities throughout the year. They are used mainly in extensive fish culture systems at the rural or subsistence level, and as on-farm feedstuffs (Ofori, 2001). The quality and quantity of nutrients available in each consignment varies according to the milling process. The local rice and corn mills do not produce by-products of the same quality during each milling process. Tilapia feed directly on these agro by-products. Ofori (2001) demonstrated that the use of rice in feeding tilapia resulted in nutrient enrichment of the water, which in turn influenced the production of phytoplankton on which the tilapia could feed. Commercial fish cage operations do not depend on these agro by-products as feed sources.

While the use of imported commercially complete feeds is popular, farmers are constrained by their high cost. To reduce these costs, farmers adopt a number of strategies. However, these do not take into consideration the slower growth and the reduction in income that may accrue to their adoption. The strategies adopted include:

- Reducing the size of the feed ration.
- Starting the production cycle by feeding commercially produced aquafeeds but then switching over to farm-made feeds during the latter stages of the production cycle.
- Pounding commercially imported feed into smaller pellets in a mortar to feed newly stocked fingerlings so that the farmer does not have to buy feeds of smaller pellet sizes, which are often more expensive.
- Those farmers feeding three times a day, including a fish cage farmer, indicated that feeding smaller quantities of feed more often resulted in reduced feed wastage.

The farmers did not maintain feed records, and thus it was not possible to verify the efficacy of their feed management practices

5. RECOMMENDATIONS

5.1 Feed production and management

On the small- to medium-scale farms, on-farm feed production and its use is not managed in a way that ensures maximum returns. The proximate composition of the feed is generally not considered. Feeding tables are not provided. Urgent attention is required on the part of farmers, extension officers and fisheries officers to rectify these shortcomings. They need to start to use feeding tables. Furthermore, they require access to information pertaining to the proximate composition of the feeds that they purchase.

5.2 Feed storage

In general feed storage facilities are poorly maintained and, in some farms feed was stored on the ground. Vermin often have access to the feed. Some feeds are kept for more than three months and are likely to have deteriorated in terms of nutrient composition and availability. Surveyed farmers found it very difficult to dry farm-

made feed during the rainy season, and the feeds often became mouldy. Those that used farm-made feeds did not optimize their feed use, leading to feed wastage. In such cases, improvements in feed management practices to avoid waste and negative impacts on water quality are required.

5.3 Research needs

The following research needs have been identified:

- Analyse the composition of farm-made feeds to determine whether the nutrient requirements of the fish are being met by the current formulations.
- Assess the feed conversion ratios (FCR) being attained under local farm conditions.

Farmers should be encouraged to take an interest in the development of the research agenda that will resolve these issues.

5.4 Legislative needs

To ensure that quality feed and feed ingredients are used, regulations are required to support efforts to ensure the certification of commercially imported feeds. By law, all feeds must provide labels outlining the nutrient composition of the feed; the manufacturers must provide feeding tables and provide an indication of the anticipated FCR. Feeds must be traceable.

5.5 Regulatory framework

There is a need for regular fish farm visits to inspect farm houses/feed stores to ensure that only certified feeds are being used by farmers. Guidelines outlining inspection procedures must be prepared to assure farmers of the legitimacy of the inspection processes.

5.6 Training

Farmer training is required to improve feed production and feed management practices. Farmers need to be taught to appreciate and understand the advantages associated with the use of good quality feed; to monitor fish growth and feed rations; to calculate FCR; to determine cost-benefit ratios; and to improve their feed formulations and choice of ingredients. It is also important to train the farmers to improve the natural productivity of their culture systems, and understand how natural productivity can improve yields. Farmers also need to be made aware of the dangers associated with overfeeding and the concomitant reduction in water quality. In this regard, non-governmental organizations and universities could provide some technical assistance in complementing government institutions to help in the development of aquaculture in Ghana. The capacity of farmer organizations should be strengthened, so that information pertaining to best management practices can be shared amongst them.

6. CONCLUSIONS

On-farm fish feed management practices are poorly understood by the farmers (e.g. the use of inappropriate feed rations leads to poor growth rates and reduced incomes). Farmers need training in terms of the preservation, storage and administration of feeds such that feeds are optimally used and profits are maximized. The review demonstrates that feed is not being stored properly by farmers and that the current farm-made feed formulations do not satisfy nutrient requirements. In this regard, there is a lot of feed wastage. Farmers do not maintain feed records and are thus unable to optimize their feed management strategies.

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