

Full Length Research Paper

Built-in rice-fish agricultural activity as a business: The case of Golinga irrigation system of small-scale farmers

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The purpose of the Golinga Rice-fish farming project was to improve the capacities of members of a Farmer Based Organization (FBO) to carry out environmentally friendly, sustainable rural farming business using Integrated Pest Management (IPM) techniques at the Golinga Irrigation Project (GIP) in northern Ghana. The project assisted small scale peasant farmers at GIP to integrate fish farming into their rice cultivation. The FBO members acquired critical IPM skills from the project demonstration farms which they applied to their own rice plots and thus improved rice productivity from mean yields of 3.5 to 4.6 - 5.8 t/ha in the project area. The project evolved a strategy for managing the FBO's two fish ponds which was based on low-input and self-reliance of the farmers. Mean fish yield from the two ponds was 2300 kg/ha which was generally higher than reported yields (500 to 1000 kg/ha) obtained from similar low-input fish ponds in the country. The arrangement helped to maximize water use efficiency and contributed to a drastic reduction in the use of chemical fertilizers and synthetic pesticides at GIP. The FBO members improved their capacities in integrated farming rice and fish and enhanced their incomes from sales of both commodities.

Key words: Rice-fish farming, integrated pest management (IPM), Golinga, *Oreochromis niloticus* (L), Katanga rice, value- chain.

INTRODUCTION

Agriculture is the mainstay of the Ghanaian Economy providing a significant share of the Gross Domestic Product (GDP) at 36%. This sector generates more than 40% of export earnings, producing over 80% of total employment and the bulk of the raw materials used by the mainly agro-based industrial sector (SRID, 2012). Fishery is a growing sector of agriculture, contributing to food and nutrition security, employment and export earnings. The fisheries sector is based on "Capture Fisheries" in large lakes, rivers and the sea. Ghana has a 550 km coastline and a total continental shelf area of about 24,300 km² to support a vibrant marine fishing industry. Ghana also has a system of rivers, lagoons, lakes and dug outs that forms the basis of an inland

fisheries industry. The importance of the fisheries sector in the social economic development of the country cannot be overemphasized. The fishing industry plays a major role in the sustainable livelihoods and poverty reduction in several households and communities (Ofori et al., 2005; Aggrey-Fynn, 2001). The sector is estimated to contribute 3.9% of the National GDP and 11% of the Agricultural GDP (Ghana Statistical Service, 2012).

In Ghana, fish is the preferred and cheapest source of animal protein with about 75% of total annual production being consumed locally. Fish provides the Ghanaian consumers with about 60% of his or her animal protein needs. The average per capita fish consumption in Ghana is estimated to be 25 kg per annum which is

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higher than the world average of 13 kg (SRID, 2012; Sarpong et al., 2005).

Annual fish requirement is estimated at 800,000 metric tons (MT), while annual production averages at 400,000 MT (SRID, 2012). This leaves an annual deficit of 320,000 MT which is made up through the importation of US\$ 200 million worth of fish into the country yearly (GEPC, 2012). Ghana can achieve the desired breakthrough in fish production both for domestic consumption and export if fish farming and aquaculture could be taken as a business. Modern techniques of integrated fish cultivation such as rice-fish farming in inland fisheries industry need to be adopted in order to achieve this goal.

BACKGROUND OF PROJECT

Integrated rice fish farming

Rice-fish culture (rizi-pisci-culture) involves stocking paddy fields (main crop) with fingerlings in order to obtain two crops, that is, fish in addition to the main crop. The strategy has been practiced for thousands of years by Asian farmers. It promotes species diversification and nutrient recycling (Coche, 1967) and ensures a more economic utilization of land resource (Dang et al., 2007). Integrated rice-fish culture aims to increase agricultural productivity from water, while improving the financial sustainability of investments in irrigation (Vincke, 1979).

Benefits of rice-fish culture include reduction in the use of chemical fertilizers and the recycling of the nutrients by the fish through feeding and depositing of faeces in the soil. This increases the uptake of nutrients such as phosphorus and nitrogen by the rice; and also contributes to improved use of land. Other gains from rice-fish integration include an increase in income from the production of both fish and rice, the spreading of biological as well as economic risks (Little and Edwards, 2003).

Choice of tilapia

Tilapia (*Oreochromis niloticus* L.) contract fewer diseases, mature quickly and can grow in environments where other species are unable to survive. The global returns for fish farming recorded by the FAO (2008) totaled 33.8 million tonnes worth about US\$ 60.0 million. Tilapia has become the third most important fish in aquaculture after carps and salmonids, with production exceeding 1.5 million metric tons in 2002 (Fessehaye 2006). Because of their large size, rapid growth (6 to 7 months to grow to harvest size), and palatability, a number of tilapiine cichlids are the focus of major aquaculture efforts, specifically various species of *Oreochromis*, *Sorotherodon*, and *Tilapia*. Unlike salmon

(*Salmo salar* L.), which rely heavily on high protein feeds, based on fish or meat, commercially important tilapias eat a vegetable or cereal based diet and thus can be raised sustainably by small farming families, for example.

Examples from Northern Ghana

In Ghana the viability of rice-fish culture was demonstrated by Kumah et al. (1996) in the Tono Irrigation Project in the Upper East region of Ghana, where averages yields of 4 t/ha of rice and 200 kg/ha of fish were obtained. ICOUR Limited (1995) have reported that in a preliminary study, Nile tilapia (*O. niloticus* L.) was successfully grown on a "No feed" regime, in a rainfed lowland rice farm. The highest yielding rice variety produced 4.8 t/ha, similar to previous rice yields at the same location. Fish growth of 121 g/fish over 139 days (four and half months) was similar to that in fish ponds being operated by small scale farmers in the same area. Ofori et al. (2005) reported similar results in a study of the effect of fish on the performance of rice and the relative economics of concurrent rice-fish culture and rice monoculture under lowland conditions at Biemso and Nobewam irrigation sites in the Ashanti region of Ghana. The evidence so far in Ghana shows that there is a lot yet to be taught and learnt about strategies such as Integration and IPM. These methods need to be evolved and demonstrated to make fish farming under rain fed lowland conditions or irrigation more widely known and adoptable.

Integrated pest and disease management (IPM)

Growing a healthy crop is the central premise of integrated crop, pest and disease management (IPM). But the teachings of IPM are not cast in stone, neither are they inviolable. IPM principles underpin the participatory Farmer Field Schools (FFS) approach for the implementation of proven and innovative technologies and strategies for affordable and improved organic farming.

One of the largest problems with freshwater aquaculture is that it can use close to a million gallons of water per acre (about 1 m³ of water per m²) each year (Hakan, 2002). Extended water purification systems however allow for the re-use of local water (recycling) in some advanced systems. In the absence of such expensive systems the Golinga project was designed such that water drained from the fish ponds was not wasted into the drains but re-directed into rice plots at a lower level with the dual purpose of recycling water and fertigating the rice farms and thus reducing the use of chemical fertilizers and maximizing water use efficiency at the GIP. In 2008 the UNDP Global Environmental Facility, Small Grants Programme approved funding

this project - IPM for Integrated Rice-Fish farming under irrigation at GIP to be implemented by a Developmental NGO, the Presbyterian Farmer Training and Community Development Project (PFT and CDP), based in Tamale in the Northern Region (N/R) of Ghana.

Goal of the project

The goal of the UNDP Global Environmental Facility, Small Grants Programme (GEF/SGP) was to implement a training and mentorship IPM project at GIP, with the key objective of developing the capacities of 55 small scale farmer to sustainable establish rice-fish farming as a business at the GIP.

Technical back-stopping for the project implementation was provided by the Council for Scientific and Industrial Research - Savanna Agricultural Research and the Water Research Institutes (CSIR-SARI/WRI) in collaboration with the Ministry of Food and Agriculture/Ghana Irrigation Development Authority (MoFA/GIDA)-Fisheries Division of northern region of Ghana. The specific objectives of the project were to rehabilitate two defunct ponds at the Golinga Irrigation Project (GIP) to demonstrate sustainable integrated rice-fish farming using IPM techniques and by way of participatory learning and action research (PLAR) methods encourage all participants to put into practice at least three of nine technologies they had learnt earlier in the season from collectively managed demonstration fields.

The beneficiaries comprised 40 male and 15 female farmers from the four major communities operating on the Golinga Irrigation Project (GIP) in the Tolon District of Northern region of Ghana, namely; Golinga, Galinkpegu, Gbulahagu and Changnaayili.

Major outputs

The major outputs of the project were to attain the following:

1. Establish a sustainable integrated rice-fish farming project based on IPM methods and practices, with the participation of at least 40 male and 15 females farmers from the Golinga, Galinkpegu and Changnaayilli communities situated around the Golinga Dam.
2. Improve land use efficiency and productivity for the participating FBO by at least 30% as a result of adoption of proven best bet farming methods of rice and fish and improved land and water management interventions, by the end of the second season of the project life cycle and
3. Achieve sustainable production of rice and fish in integration for at least 55 small scale famers (FBO) at the Golinga Irrigation Scheme.

Key project activities planned

A project implementation team from the Council for

Scientific and Industrial Research- Savannah Agricultural Research Institute (CSIR-SARI) carried out training and mentorship programme sponsored by the UNDP GEF/SGP. The project activities centered hands-on, learning-by-doing spanning 2008 to 2010. As part of the project's strategy, the following planned activities were crucial in order to build the capacities of the small scale rice farmers at the GIP:

1. Establish an IPM underlined rice-fish farm as a sustainable environmentally friendly rural based business.
2. Conduct training sessions on value chain thinking. A thorough understanding of the rice-fish value chain; adding value to produce by producing excellent quality produce; adding value where possible by way of post harvest handling; good storage facilities; intermediate technologies for rice and fish processing and good marketing strategies.
3. Acquire basic skills in farm budgeting and basic record keeping.
4. Developing action business plans to guide to group.
5. Good seed and dependable source of fry such as WRI.
6. Sustainable and cost effective farm management using best bet proven aquaculture and agronomic cultural practices.
7. Good harvest and post harvest handling practices to obtain clean produce free of stones, mud balls, debris weed seeds, thrash.
8. Threshing of rice using tarpaulins or on threshing floors to avoid stones in produce.
9. Improving yields of rice and fish with high benefit: cost ratios or high returns on their Investments.
10. Increasing knowledge of how much rice produce would be required by processors and how much stored rice to be sold at premium prices at peak price periods.
11. Have strong FBOs or farmer co-operatives to be able to aggregate their produces to attract large scale buyers such as AMSIG (Ghana) a local NGO and processing entity, Frederic Kwei Enterprise, CCCT Ghana Ltd and others in Northern Ghana; and make good bargains with input supplies
12. Understanding of Contractual Agreements with potential buyers such as AMSIG Resources, a local rice processor with supply links with the FAO.
13. Inventory credits arrangements with Developmental NGOs to avoid selling their produce to middlemen at give away farm gate prices.

MATERIALS AND METHODS

Rice farms and fish ponds

Key activities carried out under the project's major outputs by ending March 2010 included the following:

1. Bushes and weeds in project area were cleared for the establishment of the Fish ponds and Rice plots.

2. The area around the two fish ponds was fenced using local wire fencing materials obtained from used/discarded old lorry tires. Metallic entry and exit gates were provided for the fenced area around the fish ponds. The wire fencing was reinforced by live fencing using special thorn bush, madrass thorn (*Pithecellobium dulce*).

3. Land preparation was carried out. This comprised tractor plough, double disc harrow, manual leveling, bunding (building of levees) and field layout.

4. The rice fields were planted directly in the first instance (wet season 2009) to Nabogu rice. In the subsequent 2009/2010 dry season the demonstrations were repeated and Nabogu rice was replaced with Katanga (that is, October 2009 to February 2010). Both rice varieties were newly released improved cultivars by the CSIR-SARI. The method of planting was row or line planting was by dibbling and line planting using twine. Field activities carried out subsequently included irrigation of planted rice fields, hand weeding of the rice plots using hand-held paddy or rotary "weeders", fertilization and general farm management of the rice plots.

5. Scheduled meetings were held between the beneficiaries and the GIP management, that is, the officers of the Ghana Irrigation Development Agency (GIDA); the Regional officer for Ministry of Food and Agriculture (DADU, Crops) and the Regional Director, CSIR-WRI- Dr Kwafo Apeyay-Adjei and CSIR- SARI Principal Research Scientist (Entomologist and IPM Specialist, Dr. Abudulai Mumuni (Figure 4).

Training using participatory learning and action research (PLAR) techniques

Training sessions were carried out by resource persons according to developed protocols for rice-fish farming (RFF). The major training modules used for capacity building of the FBOs included: Correct selection of sites for RFF; weed control and fertilizer management in rice fields; insect pests of rice and their natural enemies; basics of organic/sustainable fish farming in the rural set up; diseases of rice and their management; rice-fish farming as a business; major diseases and pests of rice and Tilapia fish and "ABC of integrated rice-fish farming using IPM approaches".

The two fish ponds, each measuring 0.40 ha, were stocked to Tilapia fingerlings at a recommended rate for the Golinga area of 7,500 fingerlings per hectare. The fingerlings and technical recommendations were provided by the CSIR/WRI in Tamale, Ghana.

Drains leading away from the fish ponds to rice fields were constructed. The ponds were fertilised with poultry manure at 10 t/ha, two weeks prior to stocking with fingerlings. In order to improve aeration and the general health of water in fish ponds it was recommended that the ponds be drained at 2 to 3 weeks intervals and fresh water from the irrigation canals added on. This excess water was led away by canals to two rice plots at the lower end of the fish pond thus fertigrating the rice plots any time excess water from the ponds was discharged.

Rice plots were established and fertilized at half rate of the recommended fertilizer rate in the district. Thus 50 kg NPK 15-15-15 fertilizer was used instead of 100 and 25 kg sulphate of ammonia instead of 50 kg. As part of the PLAR training farmers were encouraged to use some of the new ideas they learnt from the demonstration plots on their farms in the season and several complied by applying approximately 3 t/ha poultry manure or 5 t/ha well decomposed cow dung in their rice plots prior to harrowing. Compliant farmers also leveled their plots, sub-divided big plots into smaller ones and created bunds or levees around them to contain water for longer periods after irrigation. Farmer Field Schools were held on a bi-weekly basis and participants were educated to understand pests and their natural enemies and how to use botanical pesticides such as neem extract, to manage pests and

diseases without unnecessary spaying with dangerous pesticides (Hakan, 2002; Matteson, 1996). The project was labour intensive and feeding for the fish was provided on a rotating basis by FBO members who brought domestic left-over, cow dung and poultry manure to the farm for feeding the fish or fertilizing the ponds; the cash value of all of which were estimated by comparing to available local prices. An estimate of the Benefit: Cost (B:C) was made at the end of each year and discussed with all stakeholders such as the trainee farmers, Agricultural Extension Agents (AEAs) operating in the area, CSIR –SARI, PFT and CDP and WRI collaborators

IPM training in rice farming covered nine essential topics: use of good certified seed, line planting, field leveling and bunding, use of chemical and organic fertilizers, botanical preparations and other IPM approaches to pest and disease control, weed management, roguing and timeliness of major agronomic practices including harvesting. All participants were encouraged to adopt three or more of these technologies, but could make changes to suit their individual needs and apply them within the season in their rice farms as part of a participatory learning and action research (PLAR) approach to technology dissemination. At the end of each season farmers' fields were selected at random and data collected over the period (dry season 2009 and wet season 2010): that is for five farmers who had adopted at least three of the taught technologies (Adopters) and five who had not adopted any at all (Non Adopters).

Each demonstration plot was divided into two sub-plots for ease of work and data collection. Five "yield plots" each 10m² area were ear marked in each sub plot for yields estimates (that is, using crop cut method). Yields data from the central IPM demonstration plots, for Nabogu in season 1 and for Katanga rice in season 2, was thus collected for comparison with farmers' yields. Data thus obtained, were subjected to statistical analysis of variance (ANOVA) using the GENSTAT discovery software (Lawes Agricultural Trust, Rothamsted Experimental Station, 2007) When statistical significance was detected, the means were separated using the Fisher protected LSD, following the ANOVA (Steel and Torrie, 1984). The analyzed results were discussed with stake holders, that is, project staff and farmers.

Other training sessions on Fish health and Nutrition were carried out with the facilitation of specialists from the CSIR- Water Research Institute (WRI).

The bane of many small rural fish farming enterprises is inadequate security. Security arrangements were therefore put in place to protect the fish farms from fish poachers and predator young crocodiles straying from the main Golinga Irrigation Dam. This included fencing the ponds area with locally made wire mesh and arranging for trainees to voluntarily watch over the area on a rotating basis in particular when the fish ponds were about ready for harvesting.

Data on cost of inputs and market prices of rice and fresh fish were collected for economic analysis of the results of the trials. Key indicators estimated included gross benefit (GB) and benefit cost (B-C) ratios. The total variable cost was the estimated cost of operations including the cost of labour for all the field activities and other agro-inputs such as organic and inorganic fertilizers (CIMMYT, 1988; Ray, 1984).

Mentorship of the FBO in value chain development

The main theme of training of the FBOs over the whole period of project implementation was how to approach fish and rice farming as a business. Specialists in this area from the International Fertilizer Centre (IFDC) were invited to hold special discussions with the association to help deepen the group's understanding and implementation of the approaches. Education on value chain development at the FBO level were therefore centred on an understanding of the fish and rice value chains – the role of "drivers" and "champions" in sustaining a value chain. The project

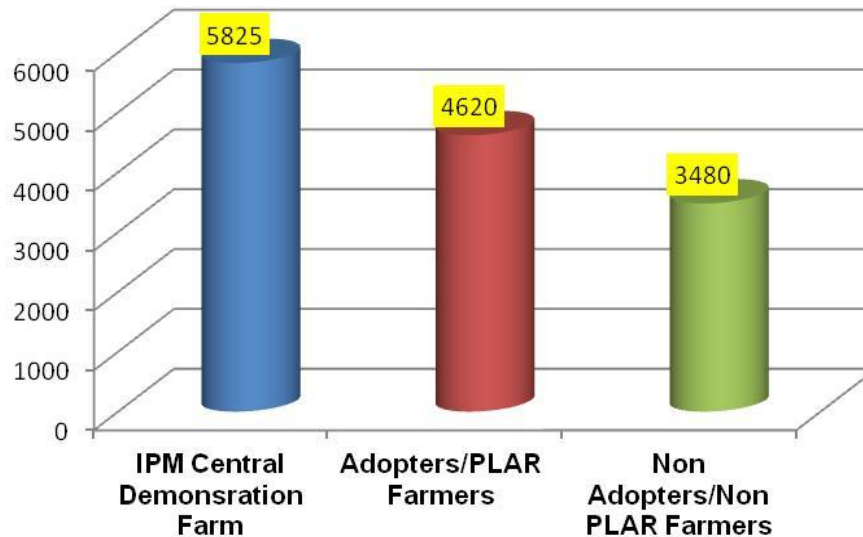


Figure 1. Yields of rice (kg/ha) from IPM Central Demonstration, adopter/PLAR and non-adopter/non-PLAR farmers' plots at GIP.

also underscored harvesting and post harvest loss management as crucial in addressing fundamental issues of value addition and market access. The decisions on choice of most marketable rice variety and produce quality expectations of different markets were informed by market surveys carried out by the participants themselves.

RESULTS

The main outcomes of the two year training and mentorship programme of UNDP/GEF/SGP "IPM for Integrated Rice-fish Farming at the GIP" are:

1. Members of the target FBO, the Golinga rice-fish farmers association acquired critical IPM skills in rice fish-farming.
2. The participating farmers were also educated on PLAR methods which they adopted and applied in their individual farms resulting in increased productivity (their average yields were as high as 4.6 t/ha compared to 3.5 t/ha of their colleagues who did not benefit from any training and mentorship (Figure 1).
3. Participants acquired important skills in value chain thinking as a result of which they produced clean rice (free of stones and mud balls etc), which sold for better prices.
4. The project farmers also now practice Contractual Agreements with potential buyers such as AMSIG resources which buy all their produce and have gone into new contracts with the FBO to continue producing in subsequent seasons.

Rice and fish farms

Over the project period two rice crops were produced and

the fish ponds harvested twice. Harvest data from these were analyzed and are summarized in Tables 1 and 2. The average yields of Nabogu rice in the wet season (5250 kg/ha) was lower than that of Katanga rice in the subsequent dry season (6400 kg/ha) (Table 1a and b). The average yields of the two varieties over the period was 5825 kg/ha (Table 1a and b and Figure 1).

Figure 1 shows a comparison of rice yields from the central IPM teaching plot (IPM) and from farms of five selected adopters (PLAR farmers) and five non-adopters (non PLAR). Average rice yields were highest (5825 kg/ha) in the IPM teaching and learning plot, followed by that of the PLAR farmers plots, with the least yields coming from the plots of farmers who did not adopt any new technology (Figure 1).

Table 2 indicates a summary of fish yields data at GIP for two ponds A and B belonging to the FBO. The measured average values of fish length, girth and yields of pond A was higher than that of pond B. Figure 3 illustrates a fish pond at Golinga while Figures 4 and 5 show different training sessions at the GIP.

DISCUSSION

Training and FBO mentorship

The practical implication of the project was that it allowed untrained small-scale farmers to learn a vital self-sustaining business of environmentally friendly rice and fish farming. The FBO participants acquired skills in value addition and meeting market expectations to improve the incomes from their farm produce.

All rice farmers operating on the GIP were aided to have contractual links to a rice processing and marketing firm called AMSIG, which subsequently assisted the



Figure 2. IPM demonstration rice plots at Golinga irrigation scheme.

Table 1a. Yields of Nabogu rice from central IPM demonstration farms plots in 2009 wet season at GIP.

Tables of means			
Variate: Yield (kg/ha) of Nabogu rice in 2009 dry season at GIP			
Sub-plot	1	2	
Mean	5216.4	5283.0	
Grand mean	5249.7		
Least significant differences of means (LSD) (5% level)			
Table	sub plot		
rep.	5		
d.f.	8		
l.s.d.	40.68		
Stratum standard errors and coefficients of variation			
Variate: Yield (kg ha)			
Stratum	d.f.	s.e.	cv%
Replication	8	27.90	0.5

Table1b. Yields of Katanga rice from central IPM demonstration farms plots in 2009/10 dry season at GIP.

Tables of means			
Variate: Yield (kg/ha) of Katanga rice			
Sub-plot	1	2	
Mean	5927	6873	
Grand mean	6400		
Least significant differences of means (LSD) (5% level)			
Table	Sub-plot		
rep.	5		
d.f.	4		
l.s.d.	155.6		
Stratum standard errors (se) and coefficients of variation (cv%)			
Variate: Yield (kg ha)			
Stratum	d.f.	s.e.	cv%
Replication	4	23.0	0.4
Replication.*Units*	4	88.6	88.6

Table 2. Fish yields data from Ponds A and B at Golinga Irrigation Project.

Fish pond	Length (cm)	Girth (cm)	Weight (g)	yield (kg/ha)
A	33.06	9.6	433.3	2400
B	27	7.17	420	2200



Figure 3. FBO managed fish pond at Golinga irrigation scheme (GIP).



Figure 4. IPM specialist Dr M Mumuni (CSIR SARI) holds discussions with farmers at GIP.

farmers with small credit packages to expand their activities. The training thus helped to develop value chain linkages and underlined an important pathway towards eradicating rural poverty, that is, by developing strategies that enhance synergies between rural agricultural production (FBOs) and rural industrial growth (Developmental NGOs such as AMSIG Resources) (Cowen et al., 1998a, b; Cristóbal, 2009).

Yields from rice and fish farms

The harvested fish from the ponds were sorted into

produce from ponds A and B. Small, medium and large fish were further sorted out according to the farmers' classification of these sizes. Pond A harvest gave a mean yield of 960 kg (2.4 t/ha) and weight of 433 g which was generally higher than that of pond B, which over the two seasons averaged 880 kg yield (2.2 t/ha) and 420 g mean weight (Table 2). Comparable results of 935 ± 29 kg/ha for feed level II (declining feed level from 4x to 2x maintenance feed) and 776 ± 22 kg/ha for level I (or maintenance feed) have been reported by Frei et al. (2006) in carp/tilapia combination trials at the Bangladesh Agricultural University, Mymensingh.

Although all management practices were similar for the two ponds over the five months average periods that the



Figure 5. Hawabu Alhassan a female FBO member at hands-on practice of use of rice “paddy rotary weeder” at demonstration site.

fishes were grown, fishes in ponds A were also generally bigger in size than those from the next pond B (Table 2). This may be explained by the fact that at each stocking, pond A was stocked two to three weeks earlier than the second pond B, but the two ponds were harvested each time at the same time because this was the best time all the FBO group members could fully participate. There were also more catfish in the first pond than the second and these fishes tend to be bigger than the main stream tilapia that were stocked. Catfish, *Clarias* spp. can breathe atmospheric air and can tolerate much higher levels of pollutants than e.g. trout or salmon which makes aeration and water purification less necessary and makes *Claris* species especially suited for intensive fish production. Despite rogeuing off catfish twice, earlier during the training periods their presence was still an additional blessing compared to one or two young crocodiles that breached the fencing and poached on the fish and had to be driven away several times.

Mean yields for Nabogu (5.3 t/ha) and for Katanga rice (6.4 t/ha) were obtained over the period from the IPM demonstration plots (Table 1). In comparison, these yields are generally above the average yields of irrigated rice (3.5 to 4.5 t/ha) from across northern Ghana (SRID, 2012; GIDA/JICA.SSIAPP-FU, 2004). The indications were also clear that growing rice and fish in integration does not depress the yield of rice as demonstrated by Frei et al. (2006) and Ofori et al. (2005). The main savings for the IPM farmers included half cost of chemical fertilizer and labour cost of fertilizer application. By use of improved systems of recycling nutrients and water, avoiding over use of chemical pesticides and improving productivity by using IPM methods and techniques the Golinga group’s production cost was

much lower, while their rice yields were better compared to those of their colleagues on the GIP (Figures 1 and 2). Roel et al. (2011), Dang et al. (2007) and Ofori et al. (2005) all have opinions similar to the conclusion of the present study that “integrated rice fish farming can provide a sustainable alternative to rice monoculture and be a viable option for diversification for smallholder farmers operating on irrigation sites such as GIP”.

Rice-fish farming over the period at GIP proved to be a profitable business (Tables 3 and 4). The project made a net profit of GHC 5,212 (US\$ 2743) for the whole business, over a period of two seasons and the B:C ratio of their rice production was at 2.48 whilst that of fish production was 1.52 (Table 5) indicating that the business was sustainable.

Using the PLAR approach helped the project to track adoption of technologies taught during the training. All 45 participants and at least 20 more non project participants at the GIP adopted one or more of the nine technologies that had been taught. But the group leaders agreed to restrict “adoption” to mean to implementing at least three of the nine taught. On this basis yields data for rice for the central demonstration, “adopters” and “non adopters” were assessed and depicted in Figure 1. The mean yield of rice from non adopters fields (3.5 t/ha) was lower than the average for irrigation farmers in the region, whose mean yields have been reported at 4.5 t/ha (GIDA/JICA, 2004).

Adopters on the average, on the other hand were able to maintain expected rice yields from irrigated project farmers of close to 4.5 t/ha, with some individuals exceeding this yield. The yields from the central demonstration rice plots were the highest at 5.8 t/ha (Figure 1) suggesting that if farmers applied more of

Table 3. Production cost of one acre rice at GIP for 2 seasons.

Input	Quantity	Unit price, GHC ^a	Total cost, GHC
Land clearing	1 acre	30	30
Ploughing	1 acre	30	30
Harowing, twice	1 acre	30	30
Land Levelling and transplanting	25 man days (md)	10	250
Rice seed	25 kg	150	75
NPK15-15-15 fertilizer (half rate)	50 kg	40	40
Sulphate of ammonia fertilizer (half rate)	25 kg	30	15
Labour cost (fertilizers application, weed and pest management, Harvest and post harvest management)			425
Miscellaneous cost (sacks, twin, storage etc)			8.95
Total cost 1 acre per season			904
Total cost 1 acre for 2 seasons			1808

^aGHC: GHC2 = 1.0 US\$.

Table 4. Production cost of two fish ponds at GIP

Cost item	Quantity	Unit cost GHC ^a	Total cost GHC
Irrigation water levies/season	50	1	50
Tilapia fingerlings	3000 fry	0.1	300
Rice bran	2400 kg	0.083	200
Poultry manure	1200 kg	0.125	150
Domestic left overs	600 kg	0.25	150
Labour-feeding, manuring and maintenance	180 days	1	180
Harvesting and post harvest processing	90 man days	2	180
Cost per season- 1 pond			1210
Cost for 2 seasons- 2 ponds			4840

^aGHC: GHC2 = 1.0 US\$.

Table 5. Economic analysis of rice-fish farming at GIP.

Item	Produce sold (kg)	Selling price/kg GHC	Total cost, 1 st season GHC	Total cost, 1 st and 2 nd seasons GHC
Fish Pond A	960	2	1920	3840
Fish pond B	880	2	1760	3520
NABOGU rice from 1 st season	2100	1		2100
KATANGA rice from 2 nd season	2400	1		2400
Gross Income from Rice fish Integrated farms for two season				11,860
Total expenditure (fish ponds and rice plots, Tables 3 and 4)				6648
Net Income				5,212
B:C ratio rice production	2.48			
B:C ratio fish production	1.52			

the technologies they learnt they could reduce cost of fertilizers and pesticides and carry out integrated rice-fish farming in a sustainable environmentally manner

Project closure

A farmers' field day rally was held at the end of November 2009 to mark the successful implementation of the two year integrated rice-fish farming hands-on training programme. A transitional "Hand-holding" period was put in place from November 2009 to March 2010. This required periodic visits, meetings and discussions between the technical team from CSIR/SARI and PFP and CDP and the FBOs which addressed key issues of project management. The GIP Rice-Fish farmers' group thereafter assumed total direct management of the project.

The implementation of rice-fish integrated farming project at Golinga allowed untrained women and men to learn a vital self-sustaining trade of farming rice and fish in close proximity using IPM methods, understanding value chain frame works and farming as a business. They are thus now not only able feed their families, but also to provide additional income to support their children. In turn, their children now have the opportunity for an education and to learn other trades. The UNDP Global Environmental facility, small grants project monitoring team's report on the project was completely satisfactory to the extent that the Golinga Rice-fish Integrated endeavour was adjudged the best agricultural small grants scheme sponsored by the facility in Ghana in recent years.

The way forward

CSIR-SARI and PFT and CDP are in discussion with the sponsors to upscale this project from 2012 to 2015 and beyond at two other irrigation sites in the region - the Bontanga and Libga Irrigation Schemes. In the specific case of GIP discussions are far advanced with the UNDP/GEF/ small Grants Project to incorporate a small poultry complex into the project so that the Golinga FBO will in the near future grow to managing a Rice-fish-poultry integrated farm.

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