A Study on Sustainability of Integrated Rice-duck Farming in Bangladesh and Its Adoption Pathways

Submitted to **Food Security Centre**
University of Hohenheim. Stuttgart, Germany

Submitted by **Shams Mustafa**
Insight Development, Dhaka, Bangladesh

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Executive Summary

Due to continuously growing population and steadily shrinking average farm sizes in Bangladesh, there is increasing need for higher rice productivity. Rice-duck farming can potentially improve productivity without relying on harmful agro-chemicals or degrading agronomic practices. In Bangladesh the rice-duck system can be implemented during the three paddy growing seasons. Ducklings start foraging the paddy field 10-15 days after rice transplanting up to the paddy flowering stage and thereby help in weeding and fertilizing the rice field. The present report deals with the technology „integrated rice-duck farming" with regard to sustainability in general and its suitability for resource-poor farmers in particular.

The location of the research was in the Northeast of Bangladesh. It was purposively selected due to the presence of an NGO, Friends in Village Development Bangladesh (FIVDB) in this area who has promoted rice-duck farming in the past. The area is in a flood plain, characterized by medium high land, clayey and loamy non-calcareous grey soils and relatively high rainfall of 4000-5000 mm per year. The field study used a mixed qualitative-quantitative approach. The quantitative segment of the study was a survey of 136 randomly selected farmers of which 80 were adopters, 37 were dis-adopters and 19 non-adopters of rice-duck farming. A series of qualitative key informant interviews (KII) have been conducted with adopters, innovators, promoters and other persons who acted as sources of information.

Adopters' characteristics and perceptions

The share of female adopters was slightly over half of the respondents (52.5 %), the overall educational level was low with 40 % of respondents never been to school and the main occupation of 52 % of respondents was agricultural production on their own farm. The average cultivated land area was 0.78 ha. About 78 % or respondents possess at least some own land to cultivate and most of the adopters have previously been involved in rice farming and duck rearing, separately. Previous rice cropping practices were characterized by the use of mineral fertilizers and insecticides, and the need for additional weeding, as described by respondents. Ducks were raised mainly on open public water bodies where ducks searched for their own feed combined with additional feeding of kitchen wastes. According to respondents, the problems related to these practices were low rice productivity, excessive use of agro-chemicals, frequent insect infestations, high labour costs, and frequent illness of ducks. Most adopters' reasons for starting rice-duck farming were their expectations of increased rice productivity, financial gain and reduced costs of production, healthier produce and reduced use of fertilizers and insecticides, as well as an increased production of eggs to meet their own and in particular their children's needs.

Respondents in the study area started the technology between 2010 and 2013. They demonstrated a good understanding of the purpose and functioning of the technology. On average, 368 ducklings per ha of land are used by respondents which corresponds to the recommended ratio.

Integrated rice-duck farming is perceived as more advantageous over the traditional rice farming in terms of rice productivity (identified by 60% of the adopters), saving of costs and working hours, decrease in the number of insects, as well as reduced need of agro-chemicals. Labour time needed is perceived as lower by 91 % of respondents and almost 94 % find it easier in terms of the skills required. The problems that rice-duck farmers are currently facing are nursing of ducklings in winter, attacks by predators, diseases, and duck health hazards through runoff from

neighbouring fields with high agro-chemical use. There is no recognition of “organic” food in the rural population.

Economic

The investments needed to start the technology (fixed costs) are BDT 1,714/PU (US$ 21.70). The gross return from rice-duck farming for the adopters was BDT 182,498/ha (US$ 2,310.44/ha), the variable production costs were BDT 91,215/ ha (US$ 1,154) and the resulting gross margin BDT 91282/ ha (US$ 1,156). The gross margin for the female adopters is 21.4 % less than that for their male counterparts. The income per day worked on the technology is nearly twice the average daily agricultural wage (BDT 260 or US$ 3.29) in the study area. This suggests the economic viability of the technology. Adopters perceived that there is no or low financial risk related to the adoption of the technology.

Social

The technology is suitable for land poor households. More than half (55%) of the adopters mentioned that their neighbours initially complained about the technology. Although there was possibility of social disturbance due to the wrongly held belief that ducks are threats to paddy plants, the experience of the adopters shows that it did not lead to any untoward incidence. The neighbours have after a while welcomed the use of ducks in paddy fields that is most likely due to the precautions taken by the adopters to prevent ducks straying on to other fields. Nearly three-quarter (71.3%) of the adopters have reported that their social status has improved. The number of working hours required over a year and an average PU are 184 hours; 141 hours for duck related activities and 43 hours for rice related activities. When specifically asked about labour/time required for the new system 90 % of the adopters reported that it was lees compared with the old system. Savings in time (and costs) can be achieved through reductions in use of insecticides, chemical fertiliser, and hired labour for weeding.

Environment

The only waste produced are 133 kg/ ha of paddy husk area by product and can be recycled. Only seven (or 19.4%) out of the 36 inputs identified by the respondents are entirely sourced from outside the community. These inputs include construction material for the duck shelter, duck feed, urea fertilizer, duck medicine and vaccines.

Dis-adopters

Most of the dis-adopters produce rice to meet family needs. Their method is to use agro-chemicals, instead of organic fertilizer. Though, some of them mentioned that the production costs of the technology are less and they continued using organic fertilizer like cow dung, even if they didn’t continue rice-duck farming. They adopted the technology for the same reasons as the adopters, but discontinued because of financial difficulties or labour shortages for taking care of the ducks in the field as well as lack of grazing land close to the homestead.

Non-adopters

The non-adopters’ practice of rice cultivation has not changed after the training provided by FIVDB. Although they were trained and received 30 ducklings from the NGO; they didn’t start the rice-duck farming. While almost 58 % perceive that the adoption of rice-duck farming is related with no or low financial risk, about 26 % perceive the financial risk as high.

Adoption pathways

The technology was identified from actual practice in a different country (not developed under any research project or institution) then its efficacy was tested for (validating the technology in the Bangladesh context), then the knowledge was diffused or extended to a wider number and locations through training (knowledge transfer) that involved revision of the knowledge package including monitoring at the early stages of knowledge practice or implementation of training, thereafter the trained farmers, first attracted attention through their performance and then themselves acted as local extension agents for those who showed an interest and willingness to implement the technology on their own. The diffusion of the knowledge from the initially trained adopters to friends or relatives also involved supervision as the former provided hands on advice at the replicators' operational sites as well as from their own homes when contacted by the former.

1 Introduction

The present report addresses the issue of sustainability of a specific agricultural innovation aimed at resource-poor farmers diversify their livelihood options and increase income through ecologically sustainable agricultural practices. It also explore the adoption pathways of the innovation. The innovation or technology addressed is the integrated rice-duck farming in Bangladesh, pioneered jointly by the Bangladesh Rice Research Institute (BRRI) and a NGO named Friends in Village Development Bangladesh (FIVDB) through a field research on an idea obtained from Japan. FIVDB has been responsible for extension of the innovation since 2006.

The study has been carried out as part of a regional project that is in the process of validating several agricultural innovations in South and Southeast Asia as part of its 'focus on the dissemination of technologies and facilitation of market access for poor farmers'. the overall objective of SATNET Asia project ('Network for Knowledge Transfer on Sustainable Agricultural Technologies and Improved Market Linkages in South and Southeast Asia') is to "contribute to improved food security and nutrition of the poorest and most vulnerable people in South and Southeast Asia by increasing and accelerating the rate of adoption of sustainable and productivity-enhancing agricultural technologies and by improving regional trade in food products. Specifically, the objective of the project is to support innovation by strengthening South–South dialogue and intraregional learning on sustainable agriculture technologies and trade facilitation".

The aim of the project is to develop a portfolio of best practices for sustainable agricultural technologies. The steps to achieve this goal are: (1) establish an analytical framework that allows the systematic assessment of the sustainability of technologies; (2) collect relevant technology options from various sources; (3) evaluate technologies to identify priority technologies; and (4) make options available to stakeholders.

The present study is a part of the third step and evaluates the rice-duck technology in Bangladesh and identifies the adoption pathways of the innovation from idea through dissemination to demonstration effect at the community level.

1.1 Bangladesh context

Given the continuously increasing population coupled with steadily shrinking farm sizes, Bangladesh is under tremendous pressure to increase, by all possible means, the production of rice, its staple diet, in order to attain self-sufficiency in food. Although increasing the size of land used for rice farming remains a remote possibility, various options for a vertical increase in rice production are still available. The present system of rice production requires the use of agro-chemicals such as fertilizers and pesticides, often in heavy doses. These chemicals, particularly the latter, are harmful to the environment as they spill into the water bodies. Moreover, resource-poor farmers often cannot afford to apply optimum doses of agro-chemicals to their rice crops to get the desired results.

1.2 Integrated rice-duck farming

In the Figures 1 and 2 pictorial description of what the technology involves and how the technology works are presented.

Production unit

The production unit (PU) consists of land and specific cropping seasons when ducks forage in the designated paddy fields. Although the scale of operation is larger in East Asian countries such as Japan, China, Indonesia the promoters of the rice-duck system in Bangladesh who have targeted the resource-poor farmers who have limited access to cultivable land and financial services, have developed a micro or homestead based design for the production unit. The recommended minimum land area to operate rice-duck farming is 0.15 acre (or 0.061 ha). However, the actual land are per adopter household on which rice-duck farming is practiced is larger than this.

Based on the experience of China in terms of the ratio of ducks to land the promoters of the technology prescribed a ratio of 350-400 ducklings per ha of land (or 21-24 ducklings per 0.061 ha of land) but in practice it has been found that the adopters applied slightly different ratio of ducklings to land depending on their resource endowment. The adopters were provided with 30 ducklings free of cost after their training by the promoters for farming on 0.061 ha land. This corresponds to a ratio of 492 ducks per ha of land and considers a mortality rate of 20 to 30%, as observed in the traditional scavenging system. The survey showed, that the actual average ratio currently practiced was 364 ducklings per ha (or 38.91 ducks and 0.130 ha) of land which is in line with the recommendation.

In Bangladesh the rice-duck system is implemented during the three paddy growing seasons known as T[1.] Aush (March to August) and T. Aman (June to December), , and Borro (November to May). The Aman and Aush seasons are rain-fed during monsoon while Borro rice is a ground water irrigated crop. The production period for the rice-duck system lasts between 3 and 3.5 months when ducklings forage in the paddy fields (see below for details).

The technology

Implementing integrated rice-duck farming includes three stages: The first stage involves preparation of the land with organic fertilizers particularly cow-dung before transplanting the rice seedlings in straight lines with prescribed spacing between lines and plants. The farmers collect chicks and ducklings of different ages as they can afford or from their own stock while land is prepared, and nursed until the next stage.

In the second stage, ducklings start foraging the paddy fields 10-15 days after transplantation during which time the plants take roots, initially for 2-4 hours a day for about a week. During this period the young ducklings are guarded against predators and straying in to other fields. Thereafter ducklings graze the fields for longer period of time, up to the paddy flowering stage which takes about 45-60 days depending on the paddy variety and cropping season.

The third step is to withdraw the ducks from the fields to prevent them from damaging the maturing grains; at this stage farmers have the choice of either continue to rear the ducks for eggs or sell them as meat. Appropriate rearing management is required until the next rice-duck season, in terms of grazing grounds (water-bodies), supplementary feeding and health care.

[1] Transplanted

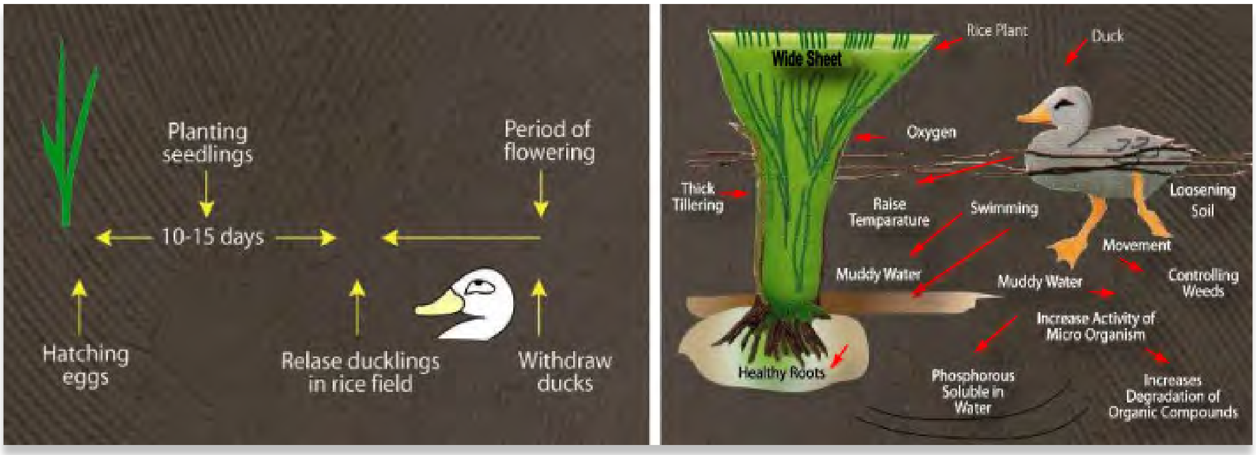

Figure 1 Method of integrated rice -duck farming (left) and technology processes (right)

Process

The technology involves basically the workings of the ducklings while they forage in the paddy fields with standing water for the duration until plant flowering (Figure 2 above[2]). While the ducks are in the paddy field:

- Their presence increases the water temperature;
- Their feet movement control weeds, loosen soil structure and soften soil, thereby
- release trapped nutrients, and improve tillering and widen the sheaf;
- They feed on unwanted insects and pests;
- Their droppings provide natural fertiliser.

Benefits of rice-duck farming

The following outcomes are derived from the integrated rice and duck farming:

- Production costs are reduced as no labour is needed for weeding and application of agro-chemicals;
- Rice yield improves;
- Production of duck eggs and meat increases thereby increasing the supply of nutrition in the food for the farmers' families;
- Farmers' income increases with two crops grown simultaneously on the same plot, per cropping season;
- Due to use of organic matters human and duck health are improved as well as environmental degradation from agro-chemicals is reduced.

1.3 Objective of the research and structure of the report

The study has the objectives to assess the sustainability of integrated rice-duck farming and to understand the pathways of technology adoption.

[2] Source: Shaikh Tanveer Hossain, Konagaya, H, Furuno, T, and Sugimoto, H (2012), "Evaluating the benefits of integrated rice-duck farming as organic system in Bangladesh", presentation at First International Conference on Organic Rice Farming and production Systems, 27th – 30th August 2012. FIVDB.

The report starts with the introduction and a description of the technology assessed in the study, followed by a description of materials and methods used before presenting the results. Chapter describes the characteristics of current adopters

of the technology from section-4 to section-8. In the latter five sections the focus is on the current practitioners of the innovations: in section-4 the profile and the earlier practices of the adopters are explored, in sections -5 to -8 selected indicators are addressed along with the study subjects' experience with the different aspects related with the innovation, namely, technical, economic, social and environmental.

The study would be incomplete without explorations of the issues that led some to decide not to apply the technology after their participation in technical training on the innovation. Chapters 7 and 8 present findings from the dis-adopters and non-adopters, respectively. Chapter 9 provides some details gathered in interviews with promoters and key informants. Conclusions are drawn in chapter 10.

2 Material and Methods

Description of the research approach

The study was composed of two major components, namely, sustainability of the technology at the farmers or practitioners' level and adoption pathway from innovation at organisational level through to practice and diffusion of the technology in the community. It heavily relied on primary data collected from different sources using mixed methods.

The field study used a mixed qualitative-quantitative approach. The quantitative segment of the study was a survey of farmers the FSC provided template has been used to develop the questionnaire which was administered in the field. 150 randomly selected farmers split into three categories were interviewed in face-to-face discussions: (i) adopters who have adopted the technology following training, (ii) dis-adopters who have been provided support from the programme of FIVDB and practiced rice-duck farming for at least one cropping season but discontinued the practice, and (iii) non-adopters who have been exposed to the technology through training from FIVDB but have decided not to adopt the technology. The sample was supposed to comprise at least 50% women), to gain an understanding of the gender perspective of the technology. The study team captured home consumption and other benefits of the technology through the questionnaire.

For the other component of the study objective – pathways to adoption, a series of KIIs have been conducted with two broad groups of individuals in order to describe the institutional and adopters' processes of technology innovation, diffusion and adoption. This description of the process has been done with KIIs with the supporting organisational level and the practitioner level. The first group are the promoters of the system, the management level of FIVDB and include the Executive Director, two Directors of FIVDB who are directly involved with the promotion of the system, and one of the two scientists who were instrumental in bringing and validating the technology in Bangladesh. They are also the institutional memories of the work done with ducks in Bangladesh for the last three decades and the process of introduction and diffusion of the system. The notes of the interviews with them are in chapter 14.2.

For the diffusion and adoption processes, five interesting cases were originally targeted for selection from the survey sample for each of whom at least three KIIs were be conducted with (a) the practitioner, (b) the person from whom the practitioner has learned how to use/ implement rice-duck farming, and (c) the person from whom this resource person has learned how to use/ implement the technology. The original definition of the interesting case as someone further innovates or modifies the system had to be changed as the notion was not understood at the field and no such cases could be found.

As an alternative definition of interesting case the stud team sought to identify those users of the technology who was not trained or supported directly by FIVDB, who may or may not modify the technology. Four interesting cases were found with the revised definition along with one FIVDB beneficiary who had scaled up the production unit. The four non beneficiaries received knowledge support from four successful adopters all of whom coincidentally were not in the sample for the survey. The there is one who received knowledge from the case who scaled up.

It was envisioned that the extension staff of FIVDB would be the resource persons from whom the beneficiaries received supervision but the programme under which the rice-duck system was being promoted had to be closed down prematurely because of changes in the home country policy of the donor and we could only interview on extension agent over telephone. The notes on the interviews of interesting cases and one extension agent are in chapter 14.3.

Study location

The study was conducted in the north eastern part of Bangladesh, in the so called Sylhet division. The location for the study was selected purposively due to the rice-duck promotion activities that have been going on in the area between 2010 and 2013. The three districts of greater Sylhet are under the Surma-Kushiara flood plain which is characterized by its medium high land, clayey and loamy noncalcareous grey soils, and an annual rainfall of 4000-5000 mm.

The villages in the two Sadar upazila of Sylhet and of Moulavibazaar are served by comparatively bigger markets and more or less two paddy crops are grown there. The topography of Jaintapur and Zakigonj are characterised by both high and low lying land while south Sunamgonj is primarily low lying land where only single cropping is possible. In the latter three upazila market access is difficult and there is high concentration of poverty.

In the three districts FIVDB's rice-duck operation is implemented in five upazila (or sub-districts). Of the five, three upazilas are in Sylhet district namely, Jaintapur (with77 participants), Sylhet Sadar (45) and Zakigonj (80), and South Sunamgonj upazila (30) of Sunamgonj district, and from Moulavibazaar district Sadar upazila (50).

Sample and sampling

The list of participants who received training from FIVDB on the technology from 2010 to 2013 formed the basis of the sampling frame. During this period a total 282 individuals from FIVDB's regular programme received training in the new system, which were distributed across the five upazila. The distribution of the participants according to upazila is as follows: 77 in Jaintapur, 45 in Sylhet Sadar, 80 in Zakigonj, 30 in South Sunamgonj and from Moulavibazaar Sadar upazila 50 (Table 1).

A proportionately stratified random sampling was done and 150 respondents were selected from the list of trainees. Of these 150, 136 could be located in the field for interviews. Of the interviewed farmers, 80 were rice-duck, 37 were dis-adopters, and 19 were non-adopters. The other 14 randomly selected persons were not available for interviewing for various reasons: six had migrated to different parts of the country, four were not found after two visits and neighbours did not know their whereabouts, three refused to be interviewed, and one migrated to the Middle East.

The distribution of the sample according to upazila is as follows: 42 in Jaintapur, 22 in Sylhet Sadar, 42 in Zakigonj, 16 in South Sunamgonj and from Moulavibazaar Sadar upazila 27.

A Bangla questionnaire has been prepared based on an English version. The Bangla translation was cross checked through back translation into English by a third person. The final Bangla questionnaire was used to collect survey data, and SPSS was used to analyse the quantitative data.

Table 1: Numbers of trainees and respondents by upazila

District	**Upazila**	**Number of trainees**	**Proportionate selection of interviewees**	**Of which**		
				Adopters	Dis-adopters	Non-adopters
Sylhet	Sylhet Sadar	45	22			

	Jaintapur	77	42			
	Zakigonj	80	42			
M.-Bazaar	Sadar	50	27			
Sunamgonj	South Sunamgonj	30	16			
Total		282	136	80	37	19

3 Adopters' characteristics, practices, and perceptions

3.1 Adopter characteristics

Education and gender

Given the scale of the technology that was designed to be of micro-size and household based for the benefit of land scarce families, it is not surprising to find that just over half (52.5%) of the adopters are females (Table 2 below). It also reflects FIVDB's aim of offering livelihood options for women that involve them in the production system thereby improving their social status as knowledge holders and users of a new technology.

Table 2: Education level and gender of adopter

Schooling Level	Sex of member		
	Female	Male	Total
No schooling	22 (52.4)	10 (26.3)	32 (40)
Primary Level	14 (33.3)	8 (21.1)	22 (27.5)
Junior School Completion	4 (9.4)	8 (21.1)	12 (15)
Secondary School Certificate	1 (2.4)	8 (21.1)	9 (11.3)
HSC+ Graduation	1 (2.4)	4 (10.5)	5 (6.3)
Total	42 (100) (52.5)	38 (100) (47.5)	80 (100) (100)

Figures in the parentheses indicate column percent (bottom row also includes row percent)

Forty percent of adopters have never been to school while a further 27.5 % went to primary school only, therefore nearly two-third are likely to be functionally illiterate (not being able to read or write a letter and carry out basic arithmetic). Among the female adopters the situation is worse compared with their male counterparts with just over half of the former (52.4%) never attended school compared with just over a quarter (26.3%) of the males. Considering functional literacy, females are nearly twice as disadvantaged (85.7%) compared with the males (47.4%).

Male adopters are better educated compared with their female counterparts: 21.1 % completed primary school and 21.1 % completed junior school.

Occupation of the adopters

The distribution of the adopters' main occupation is reported in Table 3. The adopters' occupation is mainly self employed farm work (52 %), 17 % do household chores. Other work is salaried employment, off-farm self-employment, and casual labour (farm and off-farm).

Table 3: Occupation of the adopters (household head)

Occupation	Number (%)
Self employed on own farm	39 (52)
Household chores	13 (17)
Salaried employed	2 (3)
Self employed off-farm	2 (3)
Casual labourer (on and off-farm), unemployed, and child of school age	4 (6)
Other	15 (20)
Total	75 (100)

Land ownership

The average are of the total cultivated land was 0.78 ha (192 decimals), ranging from 0.04 ha to 3.16 ha. As for the ownership of the cultivated land, 27.5 % own their land, 22.5 % lease or mortgage their land and 50 % cultivate land parcels that are both owned and leased.

Table 4: Land ownership

Responses	Frequency	
	Number	Percent
Own land	22	27.5
Rented land (lease/mortgage)	15	22.5
Both (owner-tenant)	40	50.0

When asked about the minimum land area that is required to meet the food needs of the household family, the average response of adopters was 0,695 ha. Based on the individually perceived minimum land area required, 45 % of adopters do not have access to sufficient land, 14 % have sufficient land, and 41 % have access to more than enough land to meet their own food needs. This suggests that the technology is also suitable for land poor households.

Starting the technology

The sample of adopters have been trained in and made the first application of the rice-duck technology in recent years under a large programme of learning (literacy for children, adolescent and adults along with livelihood enhancement through training on unconventional skills) that scaled up earlier FIVDB experiences on education. The year of first operation of the technology most frequently cited is 2013 by 36.3 % followed by those trained and started (28.8%) four years ago in 2010 and then those (20.0%) in 2012 (Table 5).

Table 5: First year of rice-duck farming

Responses (starting year)	Frequency	
	Number	Percent
2013	29	36.3
2012	16	20.0
2011	12	15.0
2010	23	28.8
Total	80	100

3.2 Traditional practices

In order to gain an understanding of the process that the respondents followed in rice farming and rearing ducks before adopting the technology, they were asked open ended questions on what was their practice was in the past.

3.2.1 Traditional practice of rice cultivation

Rice farming is not new to the respondents as 95 % reported to have cultivated paddy before adopting rice-duck farming. Respondents cultivated rice in both the winter (irrigated) and monsoon seasons (combined 40.0%) while 15 % preferred the dry, winter season alone.

Table 6: Rice farming practice

Identified Response	Identified by	
	Number	Percent
Rice farming before (yes)	76	95.0
Cultivation season		
Monsoon season	4	5.0
Winter season	12	15.0
Both seasons	32	40.0
Input used		
Irrigation	9	11.3
Weeding (wage labour)	26	32.5
Chemical fertilizer	65	81.3
Insecticide	59	73.8
Cow dung and compost	12	15.0
Transplant seedlings into line	3	3.8

Their practice of rice farming was based on the extensive use of agro-chemicals as reported by a large number of the respondents. From the identified information on the type of inputs used by the sample it is clear that they applied traditional method of cultivating HYV rice using chemical fertilisers, insecticides, labour for weeding. However, there is a small group of 12 adopters who reported to use organic fertiliser but they did not specify at what point or stage of the plant growing cycle.

- The use of chemical fertilizers was very widespread (81.3 %);
- Insecticide use was identified by more than two-third (73.8%) of them;
- The need for de-weeding was identified by nearly one-third (32.5%);
- There was some practice of using organic fertilizer (15%).

It appears that when responding to the question they might have recalled those information that was provided to them during training on the technology as those they would not need in the rice-duck system.

3.2.2 Traditional practice of duck raising

Duck rearing is ubiquitous in the Sylhet region because of the presence of large numbers of perennial and seasonal water bodies due to the naturally created land-depressions. Therefore it si not surprising that 88.8 % of respondents reported to have reared ducks before undertaking the new technology (Table 7). However, the rearing management that they practiced was very different from the way it is applied under rice-duck farming. The practice was to keep ducks away from the paddy fields as the data on the location of ducks' feeding grounds indicates. As expected no one used paddy fields for rearing/grazing ducks before starting to practice rice-duck farming.

Table 7: Distribution of responses on traditional practice of duck rearing

Identified response	**Reported by**	
	Number	**Percent**
Duck rearing before (yes)	71	88.8
Location of rearing duck		
Open water-bodies	48	60
All of above	10	12.5
Own pond	8	10
Neighbours' pond	2	2.5
Feeding practice		
Thrice a day extra food	26	32.5
Once a day extra food	8	10
Twice a day extra food	4	5
No extra food given (not a single time)	2	2.5
Food from kitchen (solid) waste	43	53.8
Gathered food from commons	37	46.3
Bought food (pre-packaged)	19	23.8
Prepared food	4	5
Medicine	6	7.5

The feeding practice that the adopters identified vary widely in terms of the number of times the ducks were fed at home and the sources of the food. Providing food three times a day was reported by 32.5 % of the respondents, 10 % reported to provide food once a day, whereas the technology requires that feeding take place at least twice a day at the place of the ducks' shelter.

As for the source of the food that might indicate the type and quality, show that the majority (53.8%) used kitchen waste including leftover food from the family consumption, and secondly, items gathered from the commons (46.3%). That nearly a quarter of the adopters (23.8%) provided food bought from the market (they reported such terms as 'poultry feed' that are available in packages, 'bought food', etc) suggests that they were aware of the need to provide balanced food even before their training.

3.2.3 Problems faced with traditional methods

The adopters were asked to identify the problems that they faced with traditional method of rice farming and duck rearing to which they identified 14 different problems related to the respective operations. These are listed in the Annex Table 41 while a summary is presented below.

Although 25 of the sample adopters (31.3%) did not understand the problems (presumably before they received training on the technology), the most frequently identified problems were reported by between 21 and 14 adopters. The more frequently identified problems are as follows:

- low levels of rice production/ yield (26.3 %)
- excessive use of agro-chemicals (25%)
- frequent insect infestation (23.8 %)
- The cost of hired labour (23.8 %)
- Frequent illness of ducks (18.8 %)
- Labour intensity of the method of rice production (17.5 %)

3.3 Farmers' technical knowledge on rice-duck farming

3.3.1 Source and place of first information

As expected nearly the entire sample (95%) first heard about the technology from FIVDB through the regular meeting of Community Learning Centres (CLC) supported by them as part of its regular intervention. Two of the sample heard about it after reading a booklet produced by FIVDB for its adult literacy programme graduates and another two from relatives and local traders, respectively (Table 8).

Table 8: Source of knowing about rice-duck farming for the first time

Responses	Identified by	
	Number	Percent
Group meeting/CLC organized by FIVDB	76	95
Outside source (Krishi Shikkha Book)	2	2.5
Neighbour/relative	1	1.3
Local trader (Mohajan)	1	1.3

As for the occasion or the place of hearing the information the regular CLC meeting is most frequently cited (78.8%) followed by the actual training (11.3%) and six reported to have heard about it from FIVDB officials that could also be at the CLC meeting or through individual contacts when the officials were on monitoring visits related with other activities (Table 9).

Table 9: Occasion of knowing about rice-duck farming

Responses	Number	Percent
CLC meeting/FIVDB	63	78.8
Training/FIVDB	9	11.3
FIVDB Officials	6	7.5
Neighbour/relative	1	1.3

On the question of the source of learning to operate the rice-duck technology FIVDB was cited as the source, the organisation that provided them the training

3.3.2 Perception on purpose of the technology

The respondents were asked about the 'purpose of the technology' and their responses were recorded in their own words often in full sentences that often included different aspects of the technology as well as their perceptions. Table 42 presents a detailed list of objectives and a summary is given below.

- *Control of insect and weed infestation* has been identified by 67.3 %: no need for pesticide (28.8%), ducks work as weeding labour (16.3%), ducks feed on insects (15%) and remove weed (7.5%);
- *Increase in productivity of two crops* has been identified by 147.6 %: increased rice yield, availability of eggs, meat production/growth and availability of meat have been identified by 91.3 %, 26.3 % and 15.0 % (each of the latter two), respectively;
- *Use of organic fertilizer* has been identified by 53.8 %: different statements have been sued to refer to organic aspects such as use of organic fertilizer instead of chemical fertilizer (32.5%), and duck droppings organically fertilise the land (21.3%);
- *Enhanced income effect* has been identified by 88.8 %: reduced expenses for fertilizer, duck food, weeding labour (40%) and earn profit and extra income from selling ducks and eggs (26.3%), and meet children's expenses from selling eggs (2.5%);
- *Health and environmental aspect* has been identified by the statement grow organic food as chemical fertilizer is harmful identified by 26.3 %.

From the above it is obvious that the income effect from increased yield, additional crop of duck produce and reduction in expenditure are likely to be stronger contributor to sustainability of the technology at the farmer level, rather than the environmental and health benefits.

3.3.3 Knowledge on the functioning of the technology

Question related with the working or the processes of the technology shall shed light on the retention and depth of technical knowledge among the adopters (Table 10).

Table 10: How does the technology work?

Identified	Identified by	
	Number	Percent
Ducks droppings work as organic fertilizer	69	86.3
Ducks work as weed cleaner/labour	60	75.0
Ducks feed on insects	54	67.5
Ducks feed on weeds	35	43.8
Ducks digging into the earth make the roots healthy	22	27.5
No need of chemical fertilizer	15	18.8
No need for insecticide	12	15.0
Less labour cost	9	11.3
Use of cow dung as organic fertilizer make paddy strong and free of chemicals	9	11.3

That the farmers have identified the three major processes of the technology – ducks feed on insect and weed thus controlling them, and organically fertilise the land by softening soil and their dropping, demonstrate their technical knowledge and understanding even after two to three years since their training is a major contributor to sustainability.

3.4 Farmers' reasons of adopting the technology

The respondents were asked about the reasons for which they had adopted the technology; in other words their objective(s) for adopting it (Table 11). The stated objectives of the adopters for accepting the technology are as follows:

- The response of 'increasing rice production' with such terms used as 'get more rice', 'yield will be good/better' etc, was identified by three-quarter (75%) of the respondents;
- Financial aspect was foremost as 52.5 % and 45 % identifying 'financial gain' and 'saving/reducing costs', respectively;
- The health aspect and environment were highlighted by 23.8 % and 22.5 % when they identified 'healthy rice, eggs and meat' and 'not to use agro-chemicals' respectively;
- Other noteworthy objectives identified include 'increase egg production' (20.0%) and 'children's need for eggs can be met' (10.0%)

Table 11: Distribution of the identified objectives for adopting the technology

Objectives identified	Identifying frequency	
	Number	**Percent**
Increase rice production	60	75.0
Financial advantage/ gain	42	52.5
Reduce and/ or save on costs	36	45.0
Healthy(organic) rice, eggs and meat	19	23.8
Not to use chemical fertilizers and insecticides	18	22.5
Increase egg production	16	20.0
Meet the needs of eggs of the children	8	10.0
We can make organic fertilizers use house and kitchen wastage	6	7.5
Save time spent (time saver)	4	5.0
Improve land fertility	3	3.8

3.5 Farmers' perception on optimal ratio of duck to land

The average land area used for rice-duck farming is 0.13 ha and the average number of ducks raised per ha was 368, ranging from 82/ ha to 1730/ ha. The median was 346 ducks/ ha. The optimally recommended duck ratio is 492/ ha. The respondents were asked about their opinion on the ratio of ducks they were raising in their paddy fields (Table 12).

Just over three-quarter (77.5%) thought that there was room for additional number of ducks compared with the number they raised in the paddy filed as the land area was large. The second response option that the ratio of duck to land area was optimal was supported by 11 respondents (or 13.6%).

Table 12: Opinion of respondents regarding duck population and land area

Response	Reported by	
	Number	Percent
I could have more ducks, the land area is more than enough to feed the ducks	62	77.5
I have the optimal number of ducks, my ducks are optimally fed with the feed they find in my paddy fields, I would not be able to feed more ducks with the paddy area I cultivate	11	13.6
I have too many ducks for the paddy are I cultivate, the ducks don't find enough feed in the small land area I cultivate, I have to give additional feed to the ducks	6	7.5
Total[1]	80	100

1: Includes one non response

The first opinion could have resulted from three situations: (i) the number of ducks per decimal of land that the technology promoters had suggested in the training for the adopters was on the conservative side; (ii) the adopters themselves had used less number of ducks in relation to the land area on which they grazed the ducks; or (iii) more plausibly, parcels of land (owned or rented) fitting the recommended size was not always available in exact proportions.

3.6 Difficulties faced with the technology

In response to the question about the difficulties that the adopters faced, the second largest frequency is those who faced no difficulties with the technology (32.5%), with the remaining 54 adopters mentioned eight difficulties (It is likely that there is an association between disease outbreaks and lack of availability of vaccines first and then medicines at some locations and/or at any specific times, as one interesting case (see KII notes) reported to happen in his area when he had to go out of his upazila to another. This is likely to be particularly true in case of vaccines as these are not readily available in the market as the government livestock department is its sole producer and distributer. On the issue of safe guarding the ducklings, the adopters erect fences (using synthetic nets) around their paddy fields and some family member stand guard at the fields who later herd them home (this is also highlighted in some of the KII notes).

Table 13). The more frequently identified difficulties are as follows:

- Death of ducks of various ages caused by (their perception of) diseases stand at 35 %;
- Attacks by predatory animals such as jackals/foxes, mongoose, etc identified by 13.8 %;
- Attacks by predatory birds particularly on chicks and ducklings reported by nearly 9 %;
- Lack of availability of vaccines/medicines was a difficulty for 7.5 %.

It is likely that there is an association between disease outbreaks and lack of availability of vaccines first and then medicines at some locations and/or at any specific times, as one interesting case (see KII notes) reported to happen in his area when he had to go out of his upazila to another. This is likely to be particularly true in case of vaccines as these are not readily available in the market as the government livestock department is its sole producer and distributer. On the issue of safe guarding the ducklings, the adopters erect fences (using synthetic

nets) around their paddy fields and some family member stand guard at the fields who later herd them home (this is also highlighted in some of the KII notes).

Table 13: Identified difficulties faced with the technology

Type of difficulties	Identified by	
	Number	Percent
Death caused by disease	28	35.0
Predatory animals	11	13.8
Predatory birds	7	8.8
Lack of vaccine /medicine	6	7.5
Lack of chick rearing knowledge	2	2.5
Lack of vaccine/medicine & hunting birds	1	1.3
Hunting birds and lack of chick rearing knowledge	3	3.8
Lack of vaccine/medicine, disease& lack of chick rearing knowledge	2	2.5
Did not face any problem	26	32.5

3.7 Respondents' comparison of rice-duck farming with former practices

The adopters were asked to compare the rice-duck technology with their previous rice farming or duck rearing practices. All of the responses were listed including those that were mentioned only once, coded and entered in to the electronic database. (Detailed responses are listed in Table 43). The respondents identified as much as 16 differences of rice-duck farming from their previous experience, ranging from increased rice production (47.5%) to vaccination of ducks (one respondent). While comparing the older and new systems for rice cultivation the respondents reported that in the latter production increased and costs are saved, working hours are saved as several activities are not needed, and agro-chemicals are not needed.

In order to understand the perception of the adopters regarding some specific aspects of the technology in comparison with their previous practice, five aspects were read out to them and asked to rank them on a three point scale of "less", "same" or ”more". The five aspects were: production cost, labour/effort and time needed, land required, output achieved, and skills required. Their responses are presented in the Table 14 below.

Table 14: Farmers' comparison of rice-duck farming with previous practice

Indicators of difference	Number of respondents (%)			Non response	N
	Less	Same	More		
Production cost	74 (92.5)	3 (3.8)	2 (2.5)	3 (2.5)	80 (100)
Labour/time needed	73 (91.3)	2 (2.5)	5 (6.3)		80 (100)
Land required	43 (53.8)	33 (41.3)	3 (3.8)	1 (1.3)	80 (100)
Output achieved	2 (2.5)		75 (93.8)	3 (3.8)	80 (100)
	Easier	Same	More difficult		
Skills required	75 (93.8)	3 (3.8)	2 (2.5)		80 (100)

The respondents have provided a very positive assessment of the rice-duck technology over their previous practice with negligible negativity and non response. In addition there is also negligible reference to there being no difference or the situation being the "same".

Except for the issue of land requirement - 41.3 % thought it was the same, for the technology as a whole over nine in ten respondents thought very positively (production cost, labour/time needed and skill requirement) about it as shown in the table above. Although it is unclear as to the reasons for which those who thought the land requirement was the same, 17 of these 33 adopters are first time users of the technology (starting it in 2013).

The labour/time requirement for operating the technology is less than the crop-only method as reported by 90 % of the respondents, which is likely to release time for other productive or leisure activities thus making the system more acceptable and sustainable from the technical point of view. As shown in the section on economic indicators the time that is required for the technology is remunerative in terms of income per day worked.

4 Economic aspects relevant for sustainability

This section presents the data in terms of economic analysis and sustainability in two sub sections: firstly a set of selected indicators identified from the SATNET Analytical Framework and secondly, specific experiences of the sample adopters. The selected indicators of economic analysis include gross margin, net income and income per labour time, while consumption of duck egg and meat at home and perception on financial risk involved in the system are presented in the second subsection.

4.1 Initial capital required

The fixed costs to start the technology are on average BDT 1,714 (or US$ 21.7) per average unit of production is required on average to purchase those items that have life span of more than one season or cycle of operation. These items relate primarily to the shed where the ducks are sheltered at night, and the materials for fencing the paddy plots to secure the young ducklings from straying on to other fields.

Table 15: Specific indicators and their assessment

Indicators	Assessment
Financial capital	Fixed cost to start the technology: BDT 1,714/ PU (US$ 21.7[3]/PU) (items that can be used beyond one cycle).
Physical capital required	Land required for starting the technology is 0.061 ha (or 0.15 acre) per PU, the adopters have on average used 0.130 ha in 2013.

The data on duck shed and the materials used in the sheds (for construction and repairing) are disaggregated in order to reflect the manner in which the adopters have responded to the question on the fixed inputs. Some respondents reported expenditure referring to the sheds as a whole and others identified specific items used in the sheds. This does not necessarily distinguish between building or purchase of the whole sheds and the inputs needed to repair an existing shed. This is so because in rural Bangladesh, particularly the poor households more frequently invest in

[3] On the basis of OANDA exchange rate available online at BDT = US$ 0.0127 (21 June 2014)

second hand materials and repair the sheds like 'patch-work' over time because they may not have the financial resources at a time for investing in a whole shed or new inputs.

Table 16: Fixed cost inputs

Inputs	Unit	Quantity/ PU	Unit cost (BDT)	Input cost/ PU (BDT)
Duck shed	Number	1	1,351 (US$ 17.10)	1,351 (US$ 17.10)
Duck shed materials				
Bamboo				
Corrugated iron sheet				
Other shed materials				
Net for plot fencing	kg	3.87	229 (US$ 2.90)	767 (US$ 9.71)
Total fixed cost	Per PU			1,714 (US$ 21.70)

For example the staff at FIVDB estimated that it would cost BDT 8,100 (US$ 102.55) to have a new duck shed built with new materials purchased from the market, for accommodating 100 ducks. The life span of the shed is between one and five years because the corrugated iron sheets used for roofing has an estimated life of five years (for the lowest quality and cheapest price) and the bamboo materials for wall will need repair after one year's use, and bamboo poles used for pillars is likely to last around three years, depending on the quality of the original material.

For the resource-poor adopters, investment of small sums perhaps on a yearly basis is more preferred than to large investments every few years, because they do not always have such sums of cash available and seldom have access to credit.

Physical capital required (in particular land to start the technology): the size of the land required to start the technology as per the recommendation of the promoters is 0.061 ha but in practice the average land size or the production unit was found to be 0.13 ha (or 0.322 acre). The fact that the adopters have devoted on average larger sized land for the implementation of the new system it means they have access to it and that it has not been identified as a problem as well as that the system does not require more land (a combined 95% of the adopters reported that it requires 'less' or 'same' amount of land) compared with conventional practice. The larger land area allotted to rice-duck farming also indicates that farmers perceive the activity on a larger scale as advantageous.

4.2 Gross margin analysis

Based on the data collected through the one-off household survey gross margins and net income have been computed for the plots where rice-duck method were used. As the data base contains data on duck related activities for one year without any seasonal break down, the rice production data used for computing gross margin and net income is the sum of the production from the different seasons in the preceding year (2013) as reported by the respondents.

The total production of rice grown under the technology has been multiplied by locally obtained prices to arrive at the gross return from rice farming, and for the duck related return the following have been used: home consumption of eggs and ducks, sale of eggs and ducks, gifting to others and those in stock on the day previous to data collection, less the opening stock of duck at the beginning of the year 2013. The prices used for computing gross return are those provided by the respondents.

Those inputs that do not have a more than one season's use and those that had to be purchased have been used to arrive at the variable cost; in other words, those inputs that are available at the homesteads (such as animal dropping, residues from paddy processing) or could be gathered from the commons (such as water hyacinth) and those not involving cash transactions, have not been used.

In the following Table 17 gross returns and income and income per day worked on the system from rice-duck farming for the year per ha are presented.

Table 17: Economic analysis in BDT (US$) per ha, average per year

Farmers and method	Gross return	Variable cost	Gross margin	Total cost	Income net
Rice-duck technology					
All adopters	182,498 (2,310)	91,215 (1,154)	91,282 (1,156)	96,222 (1,218)	86,276 (1,092)
Female adopters	174,177 (2,205)	89,779 (1,137)	84,398 (1,068)	92,532 (1,171)	81,644 (1,034)
Male adopters	191,694 (2,427)	92,803 (1,175)	98,891 (1,252)	100,299 (1,270)	91,395 (1,157)

The gross return for the adopters was BDT 182,498/ha (US$ 2,310.44/ha), the variable production costs were BDT 91,215/ ha (US$ 1,154) and the resulting gross margin BDT 91282/ ha (US$ 1,156). The gross margin for the female adopters is 21.4 % less than that for their male counterparts, which is likely due to smaller scale of operations or efficiency effect or combination of both.

The net income is arrived at by factoring in an allowance for the depreciation of the fixed costs (at the rate of 0.33 reflecting a life span of three years) in the total cost. The income level (BDT 86,276/ha and US$ 1,092/ ha) reflect the micro scale of rice-duck production. Yet, the income per day worked on the technology stands at nearly twice the average daily agricultural wage (BDT 260 or US$ 3.29) in the Sylhet region after making an allowance for labour cost in the variable cost. This suggests the economic viability of the technology. This is further supported by the fact that the average operation size of adopters is larger than the minimum area recommended by the promoter.

The technology also allows for savings in costs and time used in operating the system compared with the rice-only method. It was reported that cost savings were made from reduced use of insecticides, chemical fertiliser, and hired labour for weeding which was done by the ducks instead (these were identified by 30 %, 15 % and 7.5 % respectively while identifying the difference between the two systems without any prompting by enumerators). When specifically asked about labour/time required for the new system 90 % of the adopters reported that it was lees compared with the old system.

4.3 Financial savings and consumption of eggs and ducks

As has been seen above the backyard raising of duck among the sample is commonly practiced (88.8%) and perhaps as a result of this only few reported to purchase ducks for consumption before adoption of the technology (26 % reported purchasing eggs and 15 % of respondents reported purchasing duck meat before adopting rice-duck farming). The consumption of egg and duck meat from homestead production has been reported by 59 (73.8%) and 54 (67.5%) respondents. A comparison of the monetary values of purchases before the technology and home consumption of duck egg and meat are presented in Table 18.####

Table 18: Status of egg and duck purchase and home consumption before and after technology adoption *(Average BDT per year)*

Status	Adopter		Both
	Female	Male	
Egg			
Purchased before technology adoption	624	625	625
Consume after technology adoption	594 (225)	1,104 (349)	836 (284)
Duck			
Purchased before technology adoption	1,371	2,046	1,692
Consume after technology adoption	474 (5.4)	778 (5.3)	618 (5.3)

Figures in the parentheses indicate the numbers of egg and duck consumed last year respectively

Among the adopters just over a third of the total egg production is consumed at home by the family members while the difference between the female and male adopters is very slim at 37.6 and 38.2 % of the production. The difference in the average number of eggs home consumed annually is larger at 225 and 349 for the female adopters compared with their male counterparts respectively and it is 35.5 % less relative to the latter. The larger number of eggs that is available from on average larger scale of production among the male adopters is the most likely explanation for this difference in egg consumption.

On the other hand there is very little difference observed with respect to home consumption of duck meat at an average of 5.3 annually.

The monetary values of purchases and home consumption, overall, show a reduction in the period after technology adoption for both egg and meat with it being larger for the latter (from BDT 1,692 or US$ 21.421 to BDT 618 or US$ 7.824). It may be due the local dietary habit in which fish is preferred or because of the high price of duck making it a cash crop. A combination of the two along with availability of fish from the commons (water-bodies) is a more plausible explanation.

4.3.1 Perceptions on financial risk of the technology

The respondents were asked to assess the financial risk associated with the rice-duck technology on a four point scale ranking the risk levels as high, medium, low and none. The level of high financial risk did not register any response. The remaining distribution of the risk levels are presented in the Table 19 below.

Table 19: Assessment of financial risk by the adopters

Risk level	Female	Male	Both
No risk	24 (57.1)	29 (76.3)	53 (66.3)
Low risk	16 (38.1)	6 (15.8)	22 (27.5)
Medium risk	2 (4.8)	3 (7.9)	5 (6.3)
Total	42 (100)	38 (100)	80 (100)

Although two-third of the response identified 'no risk' as the most frequent with 66.3 % relatively fewer female adopters (57.1%) are found in the risk level compared with their male counterparts (76.3%). There are more females (38.1%) in the risk level of 'low risk' that implies presence of some financial risk – or at least perceived, associated with the technology, compared with the males (six or 15.8%). However, when the 'no and low' risk levels are taken together relatively more females (95.2%) are observed in the lower end compared with males (92.1%) at the margin. The frequencies at the lower end or the risk spectrum may be a reflection of women's generally cautious approach to financial matters.

5 Social aspects relevant for sustainability

This section presents data in order to assess the social sustainability of the technology in terms of four selected indicators and experience of the adopters in terms of social reaction to the technology. The SATNET prescribed indicators include land ownership, number of employees, working hours required to operate the system, potential disturbance, and share of women adopter, while the adopter experience is captured with reaction of neighbours and change in their social status.

5.1 Land ownership

Ownership of cultivable land has been used as a proxy indicator for poverty in Bangladesh since the mid-1970s, and the rice-duck technology was thought of as appropriate for resource-poor farmers. The ownership of operated land for rice farming with and without ducks suggests that the sample of adopters is a mixed group in terms of poverty status (Table 20).

Table 20: Status of cultivable land ownership

Operated land	Frequency	
	Number	Percent
Owned land only	22	27.5
Rented land only	18	22.5
Owned-rented land	40	50.0
Total	80	100

Households without any cultivable land ownership who are more likely to be on lower reaches of poverty, account for 22.5 % (18 households) while those who operate self-owned land who are likely to be non-poor, account for just over a quarter (27.5%). Exactly half of the sample is owner-tenant farmers that suggest the households do not own suffient land for subsistence farming and whose poverty status is worse than those who operate self-owned land only.

The average size of owned land is fractionally under an acre (0.992 acre) while it is little smaller (0.928 acre) in case of rented land that is nearly twice the upper limit (0.5 acre) used for targeting by poverty reduction interventions of NGOs and the government's land redistribution and safety net programmes.####

5.2 Employment potential and work load

Number of employees: Although none of the adopters reported to employ wage labour on any full or part time basis it is found in the data on time spent on operating the system that four and six respondents reported that they respectively used wage labour for land preparation and paddy harvesting purpose. However, the employment period for the hired labour is not available. The activities required in the system are conducted by the adopters and their family members particularly women.

Table 21: Employment and workload related criteria

Indicators	Assessment
Number of employee (non family) per Production Unit	None needed or generated
Number of working hours required per production unit	184 hours over a year/ average PU
Potential disturbance	Initially few non-adopter neighbours expressed their concern that ducks might damage their paddy but eventually the technology was welcomed
Share of women adopter	52.5 %

Number of working hours: the number of working hours devoted to the operation of the technology has been collected for: land preparation including tilling and transplanting the seedling, watering the land, tending to the plot such as de-weeding, harvesting of paddy, herding ducks to and from the field, caring for the ducks such as feeding and egg collection, and cleaning of duck shed. The respondents provided the number of hours and minutes spent on each activity per year or per week with in a season.

In order to contextualize the data on number of hours worked on the system, relevant responses from the respondents are presented below, while comparing the new system with old method of cultivation. They identified some specific tasks that they needed to perform in the older system that are not needed as much under the technology. Thus they are saving time that would have otherwise needed to be used:

- The technology was compared with the old system by 90 % of the adopters as requiring less labour/time;
- There being 'no or less need for chemical fertilizer' and 'for insecticide' cited by 45 % of the adopters for each;
- There being no need for de-weeding the field reported by 42.5 %;
- Thirty percent reported that there was no need for hired labour.

Use of family labour: The sources that have been identified as sources of reducing effort or as a result of rice-duck farming are all related with rice production and little has been learnt about the system's impact on women's time spent in rearing management of ducks. In fact, the major share of the labour hour devoted to the system is for caring for the ducks including herding and safe guarding; the time spent in duck related activities is 141 hours per year (leaving only 43 hours for rice related activities). It is the family labour that is responsible for these hours or work and it is the women and adolescent boys and girls who provide those unremunerated hours that are not recognised socially or in official statistics.

5.3 Acceptance of the technology in the social environment of adopters

In the social context the adopters' experience related to two issues have been addressed, namely reaction of the neighbours to the technology and changes in social status for the adopters as a result of the technology.

Potential disturbance: Although there is a generally perceived belief in the country that ducks are a threat to paddy fields because they would destroy the young plants, flowering plants or maturing plants. At the initial period of adoption of the system most adopter experienced some questioning from their neighbours, to which they responded with patience and then ensuring that the ducklings did not stray on to the fields of neighbours by first erecting fences around the duck grazing fields and herding them to and from the field as well as having someone standing guard at the field. The neighbours were won over in a short period of time (see below 'reaction of neighbours).

Reaction of neighbours to the technology

Although just over two-third (68.8%) of the adopter reported that neighbours initially complained about the technology not many either could recall exactly what was the complaint or that it might not have been serious. The neighbours' complaints reflected a commonly held (mis) belief that duck are harmful for paddy fields such as that they cause damage to paddy plants (12.5% adopters reporting) and seedlings (8.8%). Seven adopters reported that they were accused of going insane or that it was an insane idea to release duckling in paddy fields, while four reported that their neighbours requested them to graze their duck on the neighbours' paddy field after initially warning them to keep the ducks away.

Table 22: Objection by neighbors against the technology

Objections	Number	Percent
Neighbour complaint	55	68.8
Specific complaints		
Duck will harm paddy plant	10	12.5
Accusation of going mad	7	8.8
Duck will harm seedling	7	8.8
Scolding adopters	5	6.3
Initially complained then accepted it	4	5.0
Initially did not allow duck near their fields	3	3.8

Change in social status

The adopters were asked if their social status has changed as a result of their application of the rice-duck technology, with pre-coded response types ('it has increased', 'there's been no change' and ‘it has declined’). The likely responses that the enumerators were to look out for improvements include: other people visit me, they want to know about the technology, I am able to help others [with new knowledge], people show more respect than before. No one has reported that their social status has declined compared with before the start of the technology. The findings are presented in the Table 23 below.

Nearly three-quarter (71.3%) of the adopters have reported that their social status has improved as a result of adoption of the technology with more of the males (31 out of 38) reporting it compared with their female counterparts (26 out of 42). That relatively fewer women than men reporting positive change is surprising because it has been found repeatedly in the context of poverty reduction in rural areas that when a woman is trained in a technical subject (such as poultry vaccination) and are successful in application their social status outside the home improves.

Table 23: Responses on change in social status, in numbers (and %)

Change in social status	**Adopters**		
	Female	**Male**	Both
Has improved	26 (61.9)	31 (81.6)	57 (71.3)
No change	16 (38.1)	7 (18.4)	23 (28.8)
Has declined	0	0	0
Total	42 (100)	38 (100)	80 (100)

6 Environmental aspects relevant for sustainability

6.1 Total use and source of inputs and quantities of output

Four indicators are used to assess environmental effect of the rice-duck technology: production mass, waste for recycling, waste for disposal, and application of organic manure. The measurement outcomes for the indicators are presented in the following Table 24.

Table 24: Quantities of inputs and outputs

Indicator	**Outcome**
Production mass	Rice: 802 kg per PU of 0.13 hectare (or 6,799 kg per hectare) in one year
Inputs from outside of the community	7 (or 19.4%) out of the 36 inputs identified by the respondents are entirely sourced from outside the community (details below).
Waste for recycling	Paddy husk: 133 kg/ha
Waste for disposal	None was reported
Application of organic manure	53 adopters (66.3%) reported

Production mass: The annual production of rice from the integrated rice-duck stands at 802 kg per production unit of 0.13 ha on average (or 6,799 kg per hectare) for the sample. The annual production of rice without using duck stands at 2,162 kg per hectare.

Waste management: For the two indicators of waste produced by the technology, namely waste used for recycling/reuse and waste disposed off registered different responses: for the former there is some residue for recycling while for the latter there is no response. Rice husk has been identified by 52 respondents (without any probing) that can be used in the preparation of food for the ducks. Use of two other residues from paddy processing – broken pieces of rice grain and rice bran, have been reported as required inputs as food for the ducks, these however have not been identified as waste for internal use. That no waste item has been identified for disposal it implies the technology does not generate any waste that needed to be discarded.

Organic manure: The application of ‘organic manure’ in rice-duck farming that has been identified by two-third of the respondents. It should be noted here that these have been identified by the respondents while recalling the different inputs needed at the start and during the operation of the technology and that they were not asked or probed for any specific or genre of inputs. The frequency measured against the indicator is more likely to be ‘at least’ and not the ‘maximum’ number who applied organic manure.

The use of organic manure suggest a drastic change in their cultivation practice from the pre-technology days when the vast majority of the respondents reported to have used chemical fertilisers (81.3%) and 73.8 % reported use of insecticides/pesticides. Currently, this has dropped to one-eighth of the adopters (or 12.5%) who reported to purchase urea fertiliser for application in the rice-duck fields.

In addition to the use of organic manure above, the respondents have identified changes in their practice (or rice cultivation management) of the technology compared with earlier method that contribute to environmental sustainability and sets the context for the above. While citing the difference between the two systems they reported that under the technology, 37.5 % used organic fertiliser, and that there was cost saving as there was need for ‘de-weeding and insecticides’ and ‘chemical fertilisers’ identified by 30 % and 15 % of the adopters respectively (without any prompting from the enumerators).

Inputs used in the technology

The respondents identified as much as 32 items when asked to identify the inputs including services that they needed at the start of the technology cycle (or at the start of each season) and those on recurrent basis. The former can be used in more than one season or production cycle while the latter are required for each cycle; these are presented in the Table 25 below as fixed cost and variable cost inputs respectively.

The 36 items that the respondents identified s the inputs that they have utilized in operating the technology, out of which nine items could be only sourced from outside the community, 15 from inside the community and from both the sources there are 12 items.

- The items that are sourced only from inside the village including personal stock are, for example, compost and compost making materials such as cow dung and water hyacinth other animal droppings, etc.
- The items that can only be sourced from outside the community include, duck shelter making materials such as wood planks, nails and wires, bamboo splinter made covering and duck feed, urea fertiliser, animal health care items (vaccine and medicine), etc.

- The items that are sourced both from within and outside the community include: chicks or ducklings, land tilling service, seed and seedlings, bamboo for making shelter and covering, items for home-made duck food such as broken rice and rice bran, etc.

Table 25: Distribution inputs according to quantity and percentage of adopters sourcing them from outside their villages

Fixed cost inputs			**Variable cost inputs**		
Inputs (unit)	Quantity/ average PU	Sourced from outside the village (% of adopters)	Inputs (unit)	Quantity/ average PU	Sourced from outside the village (% of adopters)
Duck Shelter (number)	1.0	90.2	Ducklings (number)	39.54	91.0
Bamboo (number)	4.88	41.8	Poultry/Duck Feed (kg)	21.11	100
Corrugated Iron Sheet (number)	5.78	100	Rice husk (kg)	28.78	87.5
Synthetic Net (kg)	3.87	100	Broken rice (kg)	9.95	63.6
Wood plank (feet)	9.56	69.6	Rice bran (kg)	69.32	44.2
Nails, clips, etc (kg)	1.22	100	Medicine	Unclear	100
			Vaccine (approx. in g)	50.0	100
			Water/irrigation	Unclear	42.9
			Seed (kg)	9.27	37.3
			Seedling (kg)	33.36	71.4
			Compost (kg)	45.57	9.3
			Cow dung (kg)	27.33	0.0
			Urea fertilizer (kg)	6.0	100
Other inputs			Other inputs		
Sac, Bamboo Post, Covering, Brick, Wire/string/rope, Polythene, Bamboo screen			Earth worm, Duck and Goat dropping, Wild vegetable Water hyacinth, Saline, Oil Cake, Insecticide		

The number of items that can be sourced only from outside the community appear low at less than 20 % the importance of the items for operational and environmental sustainability is crucial. In addition, the items that are sourced from both inside and outside the community are those items for which the community supply is not sufficient to meet demand. Any severe or prolonged shortage of packaged feed, vaccines or medicine may jeopardize the adopters' investment and sustainability, even though such shortages have not been reported by the adopters.

6.2 Biodiversity

The adopters were asked about any changes they might have noticed around the land where they carried out rice-duck farming, and their responses were recorded against a pre-coded list with specific responses regarding insects, birds or any other animals. The adopters made one observation each related to insects, birds or other animals (Table 26). Just under a fifth (18.8%)

‘did not try to observe/notice’ any change; in other words did not observe any change in the surrounding areas.

Table 26: Changes observed in the area surrounding the rice-duck farms

Adopter response	Responded by	
	Number	Percent
Yes, I observed a slight decrease in the number of insects	29	36.3
Yes, I observed a large decrease in the number in insects	19	23.8
No I did not try to observe/notice	15	18.8
Yes, I observed a large increase in the number of birds	3	3.8
Yes, I observed a slight increase in the number of birds	6	7.5
Yes, I observed a slight decrease in the number of birds	7	8.8
I observed a large increase in the number of insects	1	1.3

A decrease in the number of insects was the most frequently made observation at 60.1 % (combining the slight and large decreases in insects) as it would be expected given the aim of the technology. On the other hand, the nine adopters or 11.3 % (combining the slight and large) who observed increase in number of birds; however, seven of them (or 8.8%) observed slight decline in the number of birds**.**

7 Dis-adopter experience

This section contains the study findings generated from interviews of those who received training and practiced the technology at least once, who did not farm rice-duck together in the season preceding field study (37 or 27% of the sample of 136 participants in training on integrated rice-duck farming). In the following three subsections present findings related to traditional practice of rice and duck farming, technical aspects of the two systems including difficulties and financial risk of the new system, and dilemma over the technology including reasons for initial adoption and discontinuation and conditions for restarting the system.

7.1 Traditional practices of rice and duck farming as implemented by dis-adopters

Current practice of rice farming

Out of the 37 dis-adopters, 28 (or 75.7%) reported to currently cultivate rice as a single crop without ducks. The objectives of own cultivation of rice are presented in the Table 27 below.

That subsistence needs are of prime concern for the dis-adopters for cultivating rice is clear from the 56.8 % and 43.2 % identifying ‘meeting family needs’ and ‘food consumption’ respectively as reasons for cultivation of rice. The first reason for rice cultivation includes consumption as food while it may also suggest exchange of the produce for other items such as edible oil or clothing through cash. On the other hand, the responses of ‘avoid indebtedness’ and ‘for family peace' suggest some households' income from the main sources of income may be insufficient compared with needs.

Table 27: Purpose of current cultivation of rice

Response	Responded by	
	Frequency	Percent
Currently cultivate rice (yes)	28	75.7
Reasons		
For own food consumption	16	43.2
For meeting family needs	21	56.8
Avoid indebtedness Not to loan/family peace	8	21.6
Healthy and tasty food	2	5.4

Inputs used

The inputs that are used in cultivation of rice as identified by the respondents (without any prompting) suggest that they use the conventional method for cultivating HYV paddy using the seed-water-fertiliser technology instead of organic method (Annex Table 46). The use of agro-chemicals is reported frequently by the respondents such as: urea fertiliser (by 59.5% of dis-adopters), insecticide (51.4%), and the term 'medicine' (13.5%) is likely to mean the Bangla term of *oushadh* which can also refer to pesticide, herbicide etc.

On the other hand, such organic material as cow-dung and compost have been identified by 13.5 % (or five individual) and 8.1 % (or three) suggesting that few of the dis-adopters may still use these at least to some degree which may be due to the awareness raised during training on the rice-duck system.

Method of rice cultivation

When asked about the method of (or how do they cultivate) rice growing the responses include some of the inputs presented above (Annex Table 46) such as agro-chemicals and they also identified such items as 'line and spacing' (by 27.0%) for transplanting seedlings and 'organic fertiliser' (24.3%) that might be result of the training on rice-duck method (Table 28 below). The need for 'de-weeding' the paddy field that is one of the major functions of duck in rice field, has been identified by 37.8 % who need to either bear the direct cost of wage labour or opportunity cost of own or family labour.

Current practice of rearing ducks

At the time of data collection just over half (56.8%) of the dis-adopters reported that currently they rear ducks (Table 29 below). The specific objectives of duck rearing as identified by the respondents, include 'for eggs' (43.2%), 'income from selling eggs' (27.0%), 'for children's consumption of eggs' (six individuals or 16.2%) and 'sell eggs to meet children's expenses' (three individuals or 8.1%).

Table 28: Method of rice cultivation

Response	Responded by	
	Frequency	Percent
Use chemical and insecticide	19	51.4
De-weeding	14	37.8
Land tilling	14	37.8
Line and space	10	27.0
Use organic fertilizer	9	24.3
Irrigation	9	24.3
Transplantation of seedling	4	10.8

Table 29: Currently rear ducks and its objectives

Response	Responded by	
	Frequency	Percent
Rear ducks currently (yes)	21	56.8
Objectives of rearing ducks		
For eggs	16	43.2
Income from selling ducks and eggs	10	27.0
Children could have eggs	6	16.2
Meet children's expenses by selling eggs	3	8.1

Inputs needed for duck rearing

Although the dis-adopters have discontinued with rice-duck farming system it appears from the inputs which they have reported that the knowledge gained from the training regarding the care of ducks are still in use. This is particularly so in terms of security for the ducks, feeding for the birds and animal health care (Annex Table 47).

- Secure shelter: security of the birds is an important consideration of the respondents as 48.6 %, 24.3 % and two individuals or 5.4 % have respectively identified 'duck shelter', 'covering' made of bamboo splinters in a conical shape used to secure the birds temporarily on the yard usually before feeding, and 'bamboo fencing' for the shelter walls;
- Feeding for the ducks: the respondents have identified items with which to prepare food at home and balanced feed bought from the market such as 'rice bran' (40.5%, purchased 'poultry feed' (29.7%), 'broken rice' (18.9%) and 'rice husk' (three individuals or 8.1 %). The need to provide balanced food or packaged poultry feed was emphasised in the revised training contents to ensure nutritional food;
- Health care: health care for the birds was emphasised in the revised training content after FIVDB took over extension of the technology, which is reflected in the items identified such as 'medicine' (21.6%) and vaccines (two individuals or 5.4%).

7.2 Dis-adopters perception on technical aspects

Specific comparison of the technology

The dis-adopter respondents were asked to compare the rice-duck technology with that of farming duck and rice separately, with respect to five outcome indicators on a three-point scale with one for less (positive) and three for high (negative). The specific indicators of comparison included: production cost, time/labour requirement, land requirement, output achieved and necessary skills.

On the whole all the indicators registered most frequencies at the lower or positive end of the scale, suggesting that compared with separate farming of duck and rice, the production cost, labour requirement, and land required are lower at the rates of 94.6 %, 81.1 % and 62.2 % respectively (Table 30 below).

The indicator of output achieved registered 'more' at the rate of 97.3 %, while eight out of ten thought the skills required was easier.

Table 30: Dis-adopters' perception on differences between rice-duck farming and the traditional method

(Percent of dis-adopters)

Areas of assessment	Assessment standard			Non response
	Less	Same/no change	More	
Production costs	94.6	2.7		2.7
Time/labour requirement	81.1	5.4		13.5
Land requirement	62.2	29.7	5.4 (2)	2.7
Output achieved			97.3	2.7
Skill requirement	**Easy**	**Same**	**Complex**	
	81.1	16.2		2.7

In other words, costs or complexity of the technology was not a major factor determining the decision of the respondents to discontinue with the technology. This set of findings corroborate with the findings on the causes of discontinuation of the technology (section 9.3 below).

Difficulties experienced with the technology

More than half (51.4) of the respondents reported that they did not face any difficulties when they did apply the technology (Table 31 below).

Table 31: Difficulties experienced with the technology

Response	Responded by	
	Number	Percent
No problems faced	19	51.4
Duck diseases	9	24.3
Predator attacks	9	24.3
Lack of availability of vaccines	1	2.7

Those who did identify the difficulties or problems that they faced with the technology, identified diseases regardless of the age of the birds and attacks by predators such as animals and large birds, each by identical 24.3 %. That predators are a problem in the rural setting is corroborated by the frequency with which shelter related inputs have been identified above.

Financial risk involved with the technology

The respondents were asked if they felt that they had taken a financial risk when they applied the technology, for which they were asked to register their response on a five point scale as presented in the Table 32 below.

Table 32: Financial risk associated with the technology

Risk level	Frequency	
	Number	Percent
Very high risk	0	0
High risk	2	5.4
Medium risk	2	5.4
Low risk	12	32.4
No risk	21	56.8
Total	37	100

As can be seen from the table the risk category of ‘very high’ did not receive any response with only two individuals each opted for the categories of ‘high’ and ‘medium’ risks. Conversely, nearly nine out of ten respondents thought the technology carried ‘low risk’ (32.4%) and ‘no risk at all’ (56.8%).

7.3 Reasons for adopting and dis-adopting rice-duck farming

Reasons for initially adopting the technology

The dis-adopter farmers had initially applied the technology for reasons similar to those reported by the adopters, and to the objectives and benefits of the system as promoted by the NGO and BRRI. Annex Table 48 presents the detailed responses in the words of the dis-adopting respondents and a summary follows.

The 16 reasons presented in the Annex Table 48 can be summarised as following.

- *Increase in production*: increases in the production of both rice (83.8% of dis-adopters) and duck (3 or 8.1%) were identified by the respondents but by very different frequencies;
- *Financial gain*: this was identified by the use of such terms as ‘lower expenses’ from no need to buy fertilizer, duck food, wage labour, etc (40.5%) and ‘extra income/sell eggs etc’ (35.1%), ‘meet children’s expenses (two or 5.4%), etc;
- *Additional crop*: gains from the extra crop of duck were identified by the use of terms as ‘gain eggs’ and ‘gain meat’ with frequencies of 32.4 % and 24.3 % respectively;
- *The health aspect and environment*: were highlighted by the use of such terms as ‘no need for insecticide’ (reported by 21.6%), ‘use organic fertilizer instead of chemical fertilizer’ (four or 10.8%), ‘for organic food -chemical fertilizer is harmful’ (three or

8.1%);

- *Other noteworthy objectives* identified include: 'free chicks from FIVDB' (five or 13.5%).

Losing interest in the technology

The dis-adopters have provided some compelling factors that prompted their decision to cease application of the technology after initial acceptance (Table 33 below). Among the five types of reasons perhaps the one related with the number or lack of family labour or support (32.4% reporting) perhaps is the only one that is outside the control of any programme but it also alludes to two wrong assumption on the part of the promoters (particularly, land for rice-duck system would be available adjacent and very close to the homestead that has implications for labour needed to look after the ducklings such as herding and safe guarding the ducklings and feeding).

Table 33: Reasons for discontinuation

Response	**Responded by**	
	Frequency	**Percent**
Financial difficulties/lack of capital/no loan support	18	48.6
No one to care for ducks/busy with other works/illness of family members or self	12	32.4
No grazing land for ducks near homestead	13	35.1
Death of duckling/ducks	8	21.6
Difficulty with management of duckling rearing/could not follow training	3	8.1

The most frequently identified factor for discontinuation is financial constraint (48.6%) arising from lack of cash available for investment requirements as seen earlier that initial expenses are not insignificant (the return may be greater), or lack of access to presumably non-usurious loan sources (such as banks or MFIs) to overcame the financial constraints. This becomes more acute in the seasons following the first application of the system, when there is no material support from any organisation and there is need to purchase ducklings for those who are not able to rear them during 'off-season'. The latter situation likely arises for two reasons: (i) those for whom raising of duck round the year is not an option such as those who identified 'lack of duck grazing land' (35.1%), or (ii) those who expected to receive free supply of ducklings in the subsequent years of training when participants received 30 ducklings each.

The two separately presented reasons in the table above are likely to be related with weak rearing management on the part of the farmers. The respondents did not identify why there were deaths of duck/lings – due to diseases or predators, but some identified the fact they could not follow or recall the knowledge on the technology that was given to them, as a reason for discontinuation.

Year of discontinuation

As can be seen from the Table 34 below out of 37 dis-adopters 30 discontinued applying the technology in the years 2012 and 2013 (combined 81.1%). Looking at it differently, of those who discontinued 51.4 % and 40.5 % first undertook the technology in 2010 and 2011 respectively.

Table 34: Year of discontinuation

Discontinuation year	Staring year			Total
	2010	2011	2012	
2010	2 (100)	0	0	2 (100)
2011	3 (60)	2 (40)	0	5 (100)
2012	10 (47.6)	9 (42.9)	2 (9.5)	21 (100)
2013	4 (44.4)	4 (44.4)	1 (11.1)	9 (100)
Total	19 (51.4)	15 (40.5)	3 (8.1)	37 (100)

Figures in the parentheses indicate row percents.

The largest drop out of rice-duck farmers appear to have taken place in 2012 when more than half of those who discontinued the technology did so in 2012 (21 or 56.8%) of whom ten farmers or 47.6 % were trained in 2010 the first year of expansion of the coverage of the technology under a new and large programme of FIVDB. The year of 2013 witnessed the second largest drop out of nine initial adopters of whom the first starting years were in 2010 and 2011 with four each.

The first two years when FIVDB expanded the coverage of the system are the years when vast majority (combined 91%) of the dis-dopters were trained, when both the training and programme departments had little experience of the system. They made modifications to their training curriculum and supervision methods to redress the situation (section 3.3 above).

Conditions for restarting rice-duck system in future

The vast majority (94.6%) of the dis-adopters has expressed a willingness to re-adopt the technology in the future (Table 35 below), and they identified the following conditions for this (in response to a question about the conditions which would encourage them to restart the technology).

Out of the seven conditions that they identified on their own – without any probing or pre-determined options for answers, four of them relate to external support while three to their own or local condition.

- External support: the conditions that are to be met by external agencies include ‘availability of loans’ presumably with low interest rate (identified by 43.2%), ‘free supply of ducklings’ (29.7%), further ‘training support’ (two individuals or 5.4%) as some had mentioned difficulties with rearing management as a reason for dropping out, and one respondent wished for ‘support for vaccines and medicine’.
- Own capacity: three of the conditions can be associated with their own ability of ‘leasing land’ (identified by 21.6%) presumably for growing rice, ‘increase their own financial strength’ (four individual or 10.8%) to enable them to make the required investment, and ‘if duck rearing can be arranged in dry season’ (three or 8.1%) presumably reported by those who prefer the monsoon season when the weather is warm and mortality of ducklings is low compared with the dry winter.

Table 35: Conditions for restarting the technology

Conditions identified	Identified by	
	Frequency	Percent

Willingness to readopt the technology	45	94.6
Conditions		
Availability of loan	16	43.2
Supply of ducklings free of cost	11	29.7
If can take lease of land	8	21.6
Increase own financial capacity	4	10.8
If there is a facility of rearing ducks in dry season	3	8.1
Training support	2	5.4
Support of medicine and vaccine facility	1	2.7

8 Non-adopters' experiences and perceptions

The non-adopters (19 or 14% of the sample of 136 participants in training on integrated rice-duck farming) are those who received training on the technology but did not apply it. The findings from this group are presented under similar heading as those for the dis-adopters except for the experience of the technology, instead of which their knowledge of the system is compared with traditional method.

8.1 Traditional practices as implemented by non-adopters

Practice of duck raising and rice cultivation

Most of the respondents have prior experience of farming duck and rice (84.2% and 89.5% out of 19 non-adopters respectively) and current engagement account for 68.4 % and 84.2 % respectively (Annex Table 49). Raising of ducks appear to have declined in the post training period or currently compared with before learning about the technology.

Objectives of rice farming

When asked about the objectives of rice cultivation currently the respondents identified subsistence related reasons using different words and phrases (*Inputs for rice cultivation*
From the inputs that the respondents reported to use for rice cultivation it is clear they are using primarily non organic method (Annex Table 50). These include: 'urea fertiliser' (reported by 73.7%) followed by 'medicine' or chemicals such as pesticide, herbicide, etc (47.4%), 'pesticide' (47.4%) along with 'wage labour' (reported by five individuals or 26.3%). On the other hand, two individuals reported to use 'compost' (10.5%). Unlike the dis-adopters the use of organic materials by the non-adopters is minimal.

Table 36 below). That they produce rice for consumption purpose is common to the two major objectives reported, namely, 'family consumption' by 86.4 % and 63.2 % identified 'meeting family expenses'.

Inputs for rice cultivation
From the inputs that the respondents reported to use for rice cultivation it is clear they are using primarily non organic method (Annex Table 50). These include: 'urea fertiliser' (reported by 73.7%) followed by 'medicine' or chemicals such as pesticide, herbicide, etc (47.4%), 'pesticide' (47.4%) along with 'wage labour' (reported by five individuals or 26.3%). On the other hand,

two individuals reported to use 'compost' (10.5%). Unlike the dis-adopters the use of organic materials by the non-adopters is minimal.

Table 36: Objectives of rice cultivation

Response	Responded by	
	Number	Percent
Family consumption	13	68.4
Meeting family expenses	12	63.2
Avoid indebtedness	2	10.5

Current rice cultivation practice

The non-adopters use a combination of land in terms of ownership with highest number of seven use both owned and rented land followed by six use rented land only who are tenant farmers and four owned land only who are land owning farmers (Annex Table 51). Similar to the inputs used the respondents use the method for cultivating HYVs of rice with agro-chemicals (84% and 89% reported chemical fertilisers and insecticides respectively). Only one respondent reported to transplant the seedlings in lines and with space between seedlings. In other words, the non-adopters' practice of rice cultivation has not changed after the training provided by FIVDB.

Objectives of duck rearing

In response to question regarding the objectives of their duck rearing activities the respondents used different terms for why they rear ducks but all the responses are related with family needs for consumption and meeting other needs from the money earned by selling the produce (Table 37 below). The specific reasons identified by the respondents include: to meet 'family need' (reported by 57.9%) followed by to 'increase family income' presumably by selling the produce (31.6%), four individuals reported that the money earned from selling produce would 'meet children's education expenses' (or 21.1%) while three respondents reported that it was 'not possible for them to buy duck produce to meet family needs' (or 15.8%).

Table 37: Objectives of duck rearing

Response	Responded by	
	Number	Percent
Meet family need/demand	11	57.9
Increase family income	6	31.6
Meet children's education expenses	4	21.1
Not possible to buy duck produce for family needs	3	15.8
It is easy to raise ducks in the canal adjacent to the village	1	5.3

Inputs need for duck rearing

Like the dis-adopters the non-adopters also place importance to the safety for the ducks, homemade food as well as purchased nutritionally balanced feed and to lesser extent bird health care (Annex Table 52). For the safety of the birds the following items have been mentioned in the interviews: 'duck shelter' (reported by 63.2%), 'covering' made with bamboo splinters (36.8%), four and three respondents identified bamboo (or 21.1%) and bamboo fence (or 15.8%) both of which are needed for the shelter respectively. For home prepared food the respondents identified 'rice bran' (52.6%) most frequently followed by 'broken rice' and 'snail' reported by four and two respondents respectively. Packaged feed or 'poultry feed' was reported by five respondents (or 26.3%). The latter food item suggest some of the knowledge provided during training is retained and applied by some of the non-adopters as poultry feed was included in the revised training materials in 2009.

Learning about rice-duck technology

Fifteen of the non-adopters attended the training provided by FIVDB (Annex Table 53). Interestingly four of the non-adopters claimed to have learnt about the technical knowledge from elsewhere

Most of the non-adopters received the knowledge (57.9%) during the period of 2010 – 2011 and six respondents in 2013 (or 31.6%). This distribution suggests that the majority or those who were trained at earlier years are likely to retain a better level of the knowledge compared with the recent ones.

8.2 Non-adopters' perceptions on technical aspects

Rice cultivation related problems

The difficulties that the respondents reported to face cultivating rice as a single crop are related with those that the rice-duck technology is to reduce or eliminate. Even though they were not asked to compare with the technology the responses from the non-adopters appear to have taken that in consideration (Annex Table 54). Their identification of such problems as 'insect and weed infestation' (36.8% and 31.6% respectively) and 'high cost of agro-chemicals' and 'low paddy yield' each reported by four respondents (or 21.1%) are the areas that the technology is designed to address.

Duck rearing related problems

Raising of ducks on its own poses problems some of which could be overcome with the integrated rice-duck farming directly and some indirectly (Annex Table 55). The most frequently cited problem is that 'frequent quarrels take place with neighbours' (36.8%) that arises from the conventional belief that ducks damage paddy crops particularly with maturing grains, while it has not been reported as such by the adopters and dis-adopters.

Other problems identified include 'more food needed for ducks' and 'deaths caused by diseases', both have been reported by four respondents each (or 25.8%), and three respondents each have identified that 'ducks are lost or go missing' and 'frequent illness' as problems.

Specific comparison of the technology

The non-adopter respondents were asked to compare the rice-duck technology with that of farming duck and rice separately, with respect to five outcome indicators on a three-point scale. The specific indicators of comparison included: production cost, time/labour requirement, land requirement, output achieved and necessary skills.

On the whole all the indicators registered highest frequencies at the lower end of the scale suggesting that compared with separate farming of duck and rice, the production cost, labour requirement, and land required were lower: reported at the frequencies of 84.2 %, 73.7 % and 47,4 % respectively (Table 38 below).

However, just over a third of the respondents (36.8%) thought land requirement was same as that needed for applying the technology. This is in sharp contrast with the other two sub samples in which cases the ‘same land requirement was reported less frequently.

Table 38: Non-adopters’ assessment of the technology compared with traditional method

Area of assessment	Assessment standard			Non response
	Less	**Same**	**More**	
Production cost	84.2	0	5.3	10.5
Time/labour requirement	73.7	5.3	10.5	10.5
Land requirement	47.4	36.8	5.3	10.5
Output achieved	15.8	5.3	68.4	10.5
Skill requirement	**Easy**	**Same**	**Complex**	10.5
	63.2	15.8	10.5	

The indicator of output achieved registered ‘more’ with the frequency of 68.4 %, while six out of ten thought the skills required was easier. The frequencies for these two indicators were much higher in the case of the other two groups of respondents.

It is not clear as to how these assessments could be made by the non-adopters because by definition they never applied the technology themselves.

8.3 Non-adopters’ practices and perception on financial aspects

Purchase of rice, eggs, and duck meat

In order to assess the proportion of respondents who have direct access to rice and duck related produce the respondents were asked if they purchased rice, duck eggs and duck meat last year. The results are presented in the Table 39 below.

Table 39: Purchase of selected items during the last year according to the adoption categories

Expenditure head/items	Non-adopter		Dis-adopter	
	N (%)	**Expenditure** (Tk/year)	**N (%)**	**Expenditure** (Tk/year)
Rice purchase	8 (42.1)	55,647 (US$ 704.497)	24 (64.9)	32,708 (US$ 414.087)
Duck egg purchase	4 (21.1)	5,070 (US$ 64.187)	13 (35.1)	6,760 (US$ 85.582)
Duck meat purchase	3 (15.8)	4,600 (US$ 58.237)	9 (24.3)	3,967 (US$ 50.223)

All of the items were purchased by proportionately fewer non-adopters compared with dis-adopters, whose mean yearly spending was higher in the cases of rice and meat while it was lower on eggs and meat. For the non-adopters the proportion reporting purchase of rice stands at 42.1 % compared with dis-adopters (64.9) and the mean expenditure (BDT 55,647 or US$ 704.497) is 70 % higher than the latter (BDT 32,708 or US$ 414.087). Expenditure on egg purchase is 24 % lower for the non-adopters (BDT 5,070 or US$ 64.187) compared with the dis-adopters (BDT 6,760 or US$ 85.582), while the spending on duck meat (BDT 4,600 or US$ 58.237) is 16 % higher than the latter (BDT 3,967 or US$ 50.223).

On the whole the non-adopters rely more on the self-provisioning for the selected food items compared with the dis-adopters who rely more on the market, which may suggest relatively better poverty status and food security through 'direct entitlement'.

Financial risk involved with the technology

The respondents were asked about their perception of financial risk associated with the technology, and their responses recorded on a five point scale as presented in the Table 40 below.

Table 40: Assessment of the risk involved with the technology

Risk level	Reported by	
	Number	Percent
Very high risk	0	0
High risk	5	26.3
Medium risk	3	15.8
Low risk	7	36.8
No risk	4	21.1
Total	19	100

As can be seen from the Table 40 the risk category of 'very high' did not receive any response with five individuals (26.3%) opted for the category of 'high risk' while for three (or 15.8%) there was 'medium risk' associated with the technology. Conversely, more than half of the respondents (57.9%) thought the technology carried 'low risk' (36.8%) and 'no risk at all' (21.1%).

The fact that four out of ten (42.1%) perceived that there is either very high or medium high financial risk associated with the technology there may be a cause for concern for the promoters of the technology. This may be due to an idiosyncratic characteristic of the individuals because they lack direct experience of applying the system, for example, in comparison with the dis-adopters.

8.4 Non-adopters perceptions on social aspects

As the misconception about ducks being harmful for paddy plants regardless of the plant growing cycle, is held very widely the respondents were asked about any objection made by neighbours regarding their duck rearing activities. Less than half of the respondents (47.4%) reported to have experienced any objections (Annex Table 56).

Should the ducks stray in to someone's paddy field it could lead to quarrels, be told off that ducks will harm paddy plants, ducks will be taken away and not returned but sometimes need to pay a fine, etc. One complaint was that ducks will eat fish if they stray in to someone's pond.

Interest in adopting the technology in future

When asked a overwhelming majority of the non-adopters (84%) expressed an willingness to adopt the technology in the future (Annex

Table 57), which is surprising as the non-adopters had participated in the training and received the 30 ducklings that were provided as incentive to start the new system but chose not to.

The conditions for starting the system in future are similar to those identified by the dis-adopters but with different frequencies. ’Availability of loan’ is the most frequently cited condition at 63.2 % followed by further ‘training’ at 42.1 % and six respondents identified the need for ‘supply of ducklings free of cost’. Further two respondents have identified their own capacity for ‘renting land’ that possibly suggests that they did not have access to grazing ground for ducks near their homes.

9 Adoption pathways

9.1 Identification of the technology

The integrated rice-duck farming that has been in practice in a number of East Asian countries such as Japan, China, Indonesia etc, has never been thought possible in Bangladesh as ducks have been known to damage maturing paddy plans and grains if they are allowed to forage the fields with standing crops. For this reason duck rearing households have been alert against even chicks and ducklings scavenging near any paddy field, including younger family members or wage labourer herding the ducks to nearby water-bodies and non-crop fields or after paddy harvest and away from standing crop depending on the number of ducks.

Against this backdrop of generally held strong belief that ducks regardless of their size/age or the crop growing cycle are harmful for paddy two agricultural scientists from Bangladesh on a study visit to Japan in 1998 discovered the practice of raising ducks in paddy fields. Following discussions with rice-duck farmers in Japan and observing a promotional video that clearly ‘showed the increase in rice tillering, root growth and yield, decrease in insects and weeds, and how the ducks soften the soil with their bill and feet movement’.

Both the scientists were impressed and felt that the method would be workable in Bangladesh, and on their return convinced the Director General (DG) of Bangladesh Rice Research Institute (BRRI) of its potential for the country. Though there were apprehensions within the Institute based on long held belief, they were allowed to send a proposal to the PETRA project then being implemented by International Rice Research Institute (IRRI) in Bangladesh.

As PETRA’s mandate was to identify and support innovations aimed at ‘increasing rice productivity’, the potential of the rice-duck farming method to enhance rice yield was recognised. There followed lengthy process of identifying an implementation modality that was acceptable to both BRRI and PETRA/IRRI. ‘Early in 2000, a first concept note developed by BRRI and submitted to PETRA was not approved. PETRA stressed that the institutional support was not in place for BRRI to make the model work, unless strategic partnerships were developed. When a new proposal was submitted in partnership with FIVDB [Friends in Village Development Bangladesh] as the leading institute in Bangladesh with duck expertise the proposal was approved.’

In July 2001 the field research on integrated rice-duck farming started in Sylhet for a three year period.

9.2 FIVDB's comparative advantage

At the end of the first decade of the millennium FIVDB was perhaps the most experienced organisation in Bangladesh with duck farming starting with development of a 'purpose built' variety of layer duck suitable for the wetlands of northeast Bangladesh particularly the Sylhet region, the Khaki Campbell from Indonesian and Indian Runner variety with Mallard variety. The work on the variety was started in the 1970s by International Voluntary Services (IVS) that has been continued by it successor FIVDB since 1981. In developing the variety FIVDB extended it to the household level in the villages as well as modified and introduced the Chinese method of hatching eggs or producing ducklings without electricity, to the micro level at the doorsteps of the farmers.

During pre-contract discussions with BRRI and IRRI the latter recognised the comparative advantage of FIVDB's work with ducks, and on the other hand FIVDB found the concept of integrated rice-duck farming to sit well within its' vision of promoting 'regenerative organic agriculture' and mission of identifying, testing and supporting alternative livelihood enhancing options for food security. A brief description of FIVDB's history related with ducks and a concern for environment helps in understanding its' motivation for taking up the rice-duck technology initially and continuing it beyond the research collaboration with BRRI and IRRI about a decade ago.

A number of current leaders of FIVDB had worked with IVS in the 1970s, such as the Executive Director and the Heads of Livelihood and Training Programmes, who shaped the development of its' vision and mission. Four aspects are noteworthy.

Firstly, nutritional deficiency that was a major concern in the 1970s-80s is still a major hurdle in as well as a major objective of the development of the country even after achieving many folds increase in food production (mainly rice) since Independence in 1971.

Secondly, perhaps the most defining factor in the emergence of the gigantic NGO sector in Bangladesh is the famine of 1974, in the aftermath of which the conventional wisdom particularly in the government and elsewhere has been to view it as a case of 'food crisis' in terms of rice grain shortage and the solution was focused on how to increase rice production. Against the conventional wisdom, for FIVDB it thought that vegetables and ducks provided a quicker potential solution for both increased food production and opportunities for income earning by poor households in rural areas. This is so because ducks need less care and feeding compared with chicken, and small and large ruminants, while vegetable growing required less land than rice.

FIVDB continued working with ducks –introducing the Chinese method of hatchery or duck production in the country and taking it to the villages, and developed and promoted organic vegetable farming on small plots throughout the year. These were scaled up from 2008 with Dutch Government support up to December 2013.

Thirdly, the IRRI managed project PETRA was aimed at testing and promoting alternative methods for increasing rice productivity, including using organic farming techniques that has also been one of the aims of FIVDB.

Fourthly, the rice-duck technology that produces rice and ducks organically as opposed to agro-chemical material was viewed by FIVDB as an innovative method that fits well in the organisation's overall aim of promoting regenerative, organic agricultural practice or technology.

9.3 Validating effectiveness of the technology in Bangladesh context

The preliminary work done by the BRRI Scientists who identified the technology indicated that the agro-ecological condition in Bangladesh was suitable for this technology, and the collaborative experiment was launched with FIVDB. The three districts in Sylhet region where the research was conducted are located in the Surma-Kashiara river systems' flood plain that receives relatively high rainfall.

Based on the experience of the research team's visit to China where the scale of rice-duck farming is very large the ratio of duck to land was derived for the research and to date FIVDB promotes the same ratio albeit on a smaller scale for the resource-poor famers at 30 ducks for 0.15 acre of land. The two major outcomes of the research are as follows.

Economic analysis: for the rice-duck farming it was found that the costs declined by 30-50 % while rice production increased by 10-15 % for the smaller scaled production units (0.061 ha) on which the trials were carried out. These results were achieved compared with the control plots that used chemical management resulting in larger gross margin[4] (see section 6 for details). However, when costs for family labour – mainly women, were imputed (for full cost analysis) the margin was negative for the former compared with a reduced positive for the latter[5].

Programme implication: the participants taking part in the training for rice-duck farming who were provided with one-two day old chicks as incentive for applying the technology, required large supply of ducklings. To overcome this problem FIVDB promoted the rice-husk based hatchery (Chinese method) at homestead level that produced mixed results: for the winter this was not very successful as mortality of ducklings was high but in the monsoon it was relatively better with lower mortality.

Problems encountered: A number of problems were encountered in addition to the availability of chicks in large numbers (that was later overcome with the diffusion of hatching knowledge/capacity at the village level).

- There was rearing management problem particularly with nursing of chicks and ducklings especially in winter, and attacks by predators such as wild dogs, foxes, mongoose, rats and some larger birds.
- Mortality was also caused by some diseases for which preventative and curative measures were not addressed at the initial stages of the research (see section 3.3 below);
- Some of the neighbours of the participants in the research were using agro-chemicals in high doses, the runoff from the crop fields to areas where ducks grazed posed health hazards for the birds;
- There was a problem with marketing of organic produce as there is no certification authority as well as lack of recognition of the value of 'organic' food among the rural population.

[4] Gross agricultural margin analysis results are from *Asian Journal of Agriculture and Development* (ud).

[5] Paul Van Mele, et al (2005), Innovations in Rural extension: case studies from Bangladesh; CABI Bioscience, IRRI and CABI Publishing.

9.4 Evolution of implementation: dissemination and management

During the process of field research and particularly after the end of the research period as FIVDB undertook to disseminate the technology to a wider community in different parts of the Sylhet region, two specific changes were needed to be made from the perspective of programme management. It is likely that as once the research project was completed the intensity of supervision and monitoring by the research team was reduced and the different departments of FIVDB became more directly involved. The two sections within FIVDB that were involved in transferring knowledge and supervising the trained participants implement that knowledge are the Training Unit and the Livelihood Enhancement Programme. They needed to adjust some aspects of their work to ensure that the technology was applied properly by beneficiaries outside of the research context.

9.4.1 Training: improving the knowledge content

After the research phase (2001-2004) when the participating farmers were trained and supervised by the research team, the training unit of FIVDB developed its own training module and the first batch of FIVDB beneficiaries were trained in 2006-2007 under a project supported by HKI. The module was revised in 2009 based on the training unit's own monitoring findings and feedback received from the field supervisors of FIVDB's programme division. Their field experiences led them to identify several issues that were either not observed during the research phase, became apparent during the post-research period following changes taking place in cropping practices in the locality or to accommodate beneficiary preferences.

The following additional information were incorporated in the revised training module and manual for the trainers:

- In order to reduce preventable mortality, in the chapter on duck diseases three new diseases were incorporated with advice on preventive and curative measures: the diseases are chronic respiratory diseases (CRD) for adult ducks, paralysis in ducks of all ages, and E-Coli in chicks.
- The revision introduced three specific feeds as supplements to crop field and home-made food with appropriate nutrients[6] for balanced feeding, namely, starter pellet, grower feed and layer feed. This was necessary because it was observed that there was a shortage of nutritious food which used to be available in the local water bodies, due to increasing use of agro-chemicals in paddy fields as a result of expansion of dry season paddy using irrigated ground water.
- The third change was brought about to accommodate beneficiary practice of grazing mixed size ducks in the paddy fields due to financial constraints, which required more space for movement of ducks. They were advised to change the distance between the lines and spacing for transplanting seedlings to 8inch by 8inch (from 6" by 8").

[6] It include five nutrients: protein, carbohydrate, fat, vitamins, and minerals

9.4.2 Supervision: improving practice of adopters

In order to provide appropriate advice on the duck grazing timing to the adopter-farmers the field supervision staff were provided better orientation with visual aids.

The message was to ensure proper timing for release of ducklings on the field such as:

- For weed control, they are to observe for availability of vegetation beneath the water;
- For insect control, observe for harmful insects with pictorial cards showing charred leafs, damaged leafs, etc;
- For fertiliser, they were provided with 'leaf colour charts' developed by BRRI that showed if there's sufficient fertiliser in the field.

9.5 Demonstration effect

Although there were some reservations among the community members about the effectiveness of the overall technology (diseases, predator attacks, etc) during the initial research the belief that ducks were always harmful for paddy plants has changed positively over the years. With the changes in the knowledge delivery system and the successful application of the method by adopter farmers at different locations in the region a number of community members who were not specifically trained by FIVDB decided to replicate the system for themselves without any formal support or supervision.

The replicators' decisions to apply the technology did not come about overnight, they were intrigued by the system at first, then became curious that led them to observe the adopters' activities closely, visiting the latter in the field and at home to discuss the process of the system during an entire season. They observed the functions of ducks in the paddy field and the changes taking place such as growth of the plants without the use of any conventional fertiliser, absence or very little presence of insects and weeds without the use of chemicals[7] or labour power. They observed increased yield of rice and weight gain of ducks as well as relatively early laying of eggs at later stage.

The relationship between the adopter and replicator (relatives, neighbours) is an important factor because without willing interaction or cooperation from the former the latter would not have been able to extract detailed knowledge. The adopters' only/primary incentive was the relationship and some prestige, and to a lesser extent a wider adoption of the system whereby they are also likely to share the land resources and thereby increase the scale of their own operation. One of the interesting cases invited her relatives and neighbours to graze their ducks in her paddy field that was larger than her own requirement (she could not afford the extra number of ducklings herself).

Availability of chicks: FIVDB diffused the knowledge on homestead based duck hatchery to the villages that created the supply source for its own needs (for providing to the trainees) and for those who purchased chicks and ducklings for subsequent replication of the system after the initial implementation and who for various reasons could not raise their own ducklings as the ducks from previous season was sold.

[7] Locally referred to as "beesh" or poison for insecticide, pesticide and herbicide.

9.6 Challenges

The primary challenge for the promoters of the technology is to arrest the rate of drop out (41.2%) as measured by the numbers who received training but either did not apply the system at all or ceased application after one cycle or season. The drop outs are caused by factors related with the individuals such as lack of investment ability and shortage of family labour, and to relatively lesser but still important, programming aspects such recruitment of individuals without access to grazing land and transfer of knowledge that was not properly understood. The technology itself is not a cause for the drop outs.

While there is high turnover there is also a strong demonstration effect with those adopting the system without any formal training or incentives from the promoters. In order to diffuse the technology further and create an atmosphere in which there is increased uptake of the system thereby expand the knowledge and practice of organic production of rice and duck eggs and meat. Such expansion also reduces environmental degradation and loss of biodiversity now evident due to expansion of HYV rice cultivation with agro-chemicals in dry season. Demonstration effects cost little or no money but create value for money already expended (or generate increased return to sunk investment).

As there is scope and willingness among the adopters to scale up their production units it is being done haphazardly and without any balance in the ratio of number of ducks to land size in which an optimum level of benefit is unlikely to be derived. It may have negative impact on expected production levels, mismanagement of duck rearing, women's time use, etc. The promoters can harness the enthusiasm and channel it for proper scaling up with new and innovative approaches. The new pilot project of FIVDB that is testing out lessons learnt from the experiences from elsewhere in East Asia, a community approach to rice-duck farming on larger scale may produce innovations.

10 Conclusions and recommendations

There are strong indications of sustainability of the rice-duck technology that has been implemented at household level, evidenced by the adopters' perceptions and performance and the independent criteria of technical, economic, social and environmental considerations.

Adopter characteristics

Formal education is not a requirement for the adoption and sustained application of the technology by the poor households provided appropriate training methods are used and monitoring of implementation is carried out at least for the first season of rice-duck farming. The technology is suitable for those with low levels of literacy. The majority of the adopters stated that the technology was not complicated.

Generation of wage employment at the scale of operation at which the technology is currelty promoted is unlikely. In fact availability of family labour to devote to the system and previous experience of rice farming make the system attractive for the adopters and therefore improves the prospects of sustainability. The lack of availability of family labour results in drop outs (dis-adopters and non-adopters) among the participants in training on the system.

The technology may not be sustainable for the poorest segment of the resource poor farmers or the extreme poor who are also vulnerable to food insecurity, for whom the imperative of daily wage earning and sustenance is overarching relative to the option of a seasonal, lumpy return.

Knowledge retention as contributor to sustainability:

It is apparent from the results, the identified problems of rice farming are those that the rice-duck technology aims to reduce such as increasing rice yield with care for the environment and reduction in production costs as ducks replace labour and agro-chemicals. That the farmers have identified the three major processes of the technology – ducks control insect and weed, and organically fertilise the land by softening soil and their dropping, demonstrate their technical knowledge and understanding the majority of whom have been trained more than two years ago (between 2010-2012). In fact, two-third of them had long to good experience of the technology between 2010 and 2012. The repeated applicators are likely to have developed sound expertise as well as derived substantial benefits from the technology.

Farmers' motivation and income effect contributing to sustainability

Adopters' motivation for adopting the technology is related with the benefits such as financial and food security issues that they derive such as from higher yield of rice, and less with organic farming. From this it is obvious that the income effect from increased yield, additional crop of duck produce and reduction in expenditure are likely to be stronger contributor to sustainability of the technology at the farmer level, rather than the environmental and health issues.

Technical sustainability

Retention and depth of technical knowledge is very high among the sample that includes those who have received the knowledge several years ago, when they described the working of the technology. The high level of knowledge retention suggests the technology is not complicated even for illiterate farmers, they were also able to successfully transfer it to others, have repeatedly implemented it, and thus perhaps the first condition of sustainability is ensured. If the farmers could not retain the knowledge and apply it well after supervision and monitoring by the

NGO was withdrawn sustainability would have failed at the first hurdle let alone cross the independent criteria.

Economic sustainability

The income per day worked on the technology stands at nearly twice the average daily agricultural wage (BDT 260 or US$ 3.29) in the Sylhet region after making an allowance for labour cost in the variable cost. This suggests the economic sustainability of the technology.

The technology also allows for savings in costs and time used in operating the system compared with the rice-only method from reduced use of insecticides and chemical fertiliser, and hired labour resulting from de-weeding done by the ducks. When specifically asked about labour/time required for the new system 90 % of the adopters reported that it was lees compared with the old system. These imply that the effort of the adopters was also reduced in operating the technology.

Social sustainability

Women's participation is high both in terms of number of adopters and the labour time they devote to duck related activities that is disproportionately few times higher than their male counterparts in the households. The technology saves time in the rice growing activities. However, as holders of specific knowledge and contributors to their families they have improved their social status at home and community. ####

Although there was possibility of social disturbance due to the wrongly held belief that ducks are threats to paddy plants the experience of the adopters show that it did not lead to any untoward incidence. The neighbours have after a while welcomed the use of ducks in paddy fields that is most likely due to the precautions taken by the adopters to prevent ducks straying on to other fields. The neighbours were won over also due to the fact that the ducklings graze the paddy fields at a certain age and size and for a specified period of time.

Environmental sustainability

The use of agro-chemicals in the rice-duck farming have been nearly eradicated; replaced by the use of organic materials such as compost and cow dung. This change will positively impact the biodiversity in the areas where the system is in use particularly if the demonstration effect is widespread. There is also no 'dumping of waste materials' as most of the by-products from paddy processing are used, in the present context, as food for the ducks.

In the following some major recommendations are offered in the context of further expansion of the rice-duck farming and further assessment of its sustainability.

Expansion of incentives: Promoters of the technology should consider supporting the beneficiaries in the form of providing the initial funds for investment in duck shelter in addition to supplying ducklings for the first cycle of production. The materials to be used in the shelters should be of a quality which can be repaired or partially or fully replaced by the adopters at a cost affordable to the beneficiaries. Use of building materials which are of high cost to repair or replace are likely to have negative impact on the financial sustainability of implementation or adoption.

Capital requirement. The adopters have devoted on average larger sized land for the implementation of the new system when they have access to it and that it has not been identified as a problem as well as that the system does not require more land compared with conventional practice the physical capital requirement is not a barrier to participation nor negatively impact sustainability of the technology. However, how the financial capital is made available is not known nor if sacrifices are made at some other detriment, which can be prevented or mediated through intervention needs to be studied.

Ensuring animal health care services. The availability of vaccines and medicine may appear to exert some negative pressure for sustainability but it is unlikely to be un-surmountable or that it will render the technology unsustainable because the farmers have 'dynamic access' to the services as shortages are temporary and location specific. Consideration may be given to development of links between the adopters and the government livestock services so that the former are accorded priority in the latter's services. Locally present NGO(s) may act as the medium to create the linkages and act as trouble shooters.

Assessment of increase in women's workload: Many rural women willingly undertake additional burden if it contributes to the family welfare particularly in support of their children in terms of nutrition, education and general wellbeing. Recognition of women's contribution for their family is at a nascent stage, and in the present context their role in the successful management of the system needs to be thoroughly identified, analysed and supportive measures to be developed.

Assessment of demonstration effect and its impact on environment/biodiversity: In future the demonstration effect may be further studied for two reasons: i) sustainability of the technology when it is replicated by community members without any formal support or incentives; and ii) the more people replicate the technology the less is the cost of dissemination of the knowledge and therefore an indication of better 'value for money'.

Scaling up the production unit: In order to gain economies of scale thereby strengthen sustainability in terms of economic and social benefits, improvement in biodiversity as well increasing the production of healthy food items.

Certification of organically produced rice: As there is little knowledge of the benefits of organically grown rice, eggs and meat among the local communities increasing awareness will not only benefit the consumers but also the producers who may derive a small premium on the prices of their produce which they don't currently. Although there are pockets of awareness of organic food in urban areas and among educated groups there is no central certification system or authority, the existence of which is likely to increase awareness, production and consumption. Efforts are needed to initiate the process for establishing a certification mechanism.

Organise training for groups from same geographic locations: The training and support should be given in a location specific cluster basis, i.e. to groups of farmers from one area; so that they can share ideas and seek support from FIVDB and GoB offices collectively. It might inspire the farmers to cooperate among themselves on technical – such as sharing of innovations, and commercial aspects – such collective marketing of their produce, of the operation.

Adoption pathway

The adoption pathway shows that when the implementing agency –FIVDB in the present context, has expertise in the wider field of the technology there may be a greater willingness on their part to continue with learning beyond the research phase and make necessary changes in the training curriculum and their supervision methods in order to support the ultimate beneficiaries. They did not consider the pilot project to be an end in itself; instead they made necessary changes and disseminated the technology to a larger number of beneficiaries as part of their regular programme intervention.

The sustainability of the technology can also be assessed by the fact that some community members, who received no formal training or material support, were convinced of the efficacy of the system to the extent that they replicated the system and invested their own resources. They invested time and money that they perceived to be worth their while. The performance of the adopters (FIVDB beneficiaries) was a major factor behind this as well as was their willingness to provide the required information to those who wished to learn about it.

11 ANNEXURE

11.1 Definitions

Production unit: The production unit (PU) consists of land and specific cropping seasons when ducks forage in the designated paddy fields. The promoters of the rice-duck system in Bangladesh who have targeted the resource-poor farmers have developed a micro or homestead based design for the production unit. The design of the PU is based on 0.15 acre (or 0.061ha) of land that is to be operated by a beneficiary or adopter household. The promoters of the technology prescribed a ratio of 21-24 ducklings per 0.061 ha of land but in practice the ratio stands at 38.91 ducks and 0.130ha of land. In the Sylhet region the rice-duck farming takes during March to November – the rain fed season and December to May the dry irrigated season.

Fixed inputs: The fixed inputs are those items that have a life/usability for more than one cropping season and in the present case these have at least 12 months durability. These are duck shed and the construction materials such as corrugated iron sheet, bamboos and bamboo made wall shuttering, net for fencing the plot, bamboo posts for the fencing, etc.

Variable inputs: These inputs are those that are consumed in a single season or recurrent items. These are the ducklings, seed and seedlings, land preparation and irrigation, urea fertilisers and insecticides, various items for preparation of compost including animal dung, packaged feed and crop residues used for duck food, vaccines and medicine for ducklings and ducks, labour cost, etc.

Costs: Costs are based on the price paid or received by the adopters when exchanging goods and services for cash. Unit costs are based on the amount paid when an item is purchased and the average is arrived at by the number of respondents who purchased it (not including those who recycled or gathered an item free of cost).

Labour days: The amount of time spent in operating or carrying out different activities related with the technology, for the following broad activities, namely, land preparation including tilling, transplanting seedlings, preparation of compost, etc, irrigation, tending to the paddy plants such as controlling weed and insecticides, herding the ducklings to fro the paddy field, caring for ducks such as feeding, collecting of eggs, cleaning the duck shed, and harvesting paddy. Data have been collected in terms of days, hours and frequency of respective activity.

Gross return: Gross return refers to the value of the total produce of one year per average production unit, including stock in hand net of opening stock.

Variable cost: Variable cost refers to the value of the costs incurred in procuring the variable inputs including opportunity cost for own and family labour as the use of hired labour is negligible, over the year per PU.

Gross margin: Gross margin is the difference between gross return and variable costs per year per PU.

Total cost: Total cost refers to the sum of variable costs and discounted value of fixed costs that has been set for the present purpose at 0.33 (assuming a three year life span based on two major materials for the duck shelters of corrugated iron sheet and bamboo materials. From the experience of FIVDB field staff the cheapest priced CI sheets has life span of five years while bamboo materials need repairs after 12 months, and the fencing net last between 12 to 36 months for varying quality).

Net income: Net income is derived by subtracting the total cost from the gross return for one year per PU.

Income per labour day: It is derived by dividing the net income by the number of days used in rice-duck farming over a year/PU.

11.2 Annex: Notes on interviews of key personnel of FIVDB

Interview 1:**Zehin Ahmed,** Execitive Director, FIVDB, 18 February 2014, Sylhet

He had met with Noel Megor, COP of PETRA project of IRRI in early 2000s, in early 1970s when he was an IVS. Visited FIVDB around 2000 to discuss possibility of experimental work with improved version of rice-duck farming. He knew about FIVDB's continuation of work on duck farming that was started by IVS at the time he was in Bangladesh. They discussed about how the duck activities in paddy field would aid in the growth of plants and yield, control insects and weed, improve fertility of land, and thereby reduce costs as well as produce an additional crop of eggs and duck meat.

There followed a three-year long field testing of the technology when initially it was difficult to convince the people about the benefits of the technology – there were deaths of ducks due to diseases and attacks by predators such as wild dogs, mongoose, rats and some birds.

FIVDB had already by then developed a purpose built variety of duck suitable for the wetlands of northeast Bangladesh particularly Sylhet area, the Khaki Campbell from Indonesian and Indian Runner variety with Mellard variety.

The notion of promotion of organic farming sits well FIVDB's mission statement of . . . "wherever there's an opportunity to reduce food insecurity of the poor we would take action . . .and when it involves organic farming it is even better"

Why ducks? Why did FIVDB decide to collaborate with IRRI?

1. Nutrition source that is cheaper than poultry (which needs intensive care) and the availability of foraging grounds for ducks; nutrient deficiency is still a major development hurdle for Bangladesh even after many fold increase in agricultural growth since Independence in 1971

2. there was a food crisis in the 1970s [with the famine of 1974] when all focus was on how to increase rice production but for FIVDB it appeared that vegetables and ducks provided a quicker potential solution for both increased food production and opportunities for income earning by poor households. as ducks need less care and feeding than chicken, and small and large ruminants. FIVDB continued working with ducks –introducing the Chinese method of hatchery or duck production in the country and taking it to the villages, and developed and promoted organic vegetable farming on small plots throughout the year. These were scaled up from 2008 with Dutch Government support up to December 2013.

3. the IRRI implemented project PETRA was aimed at testing and promoting alternative methods for increasing rice production/productivity, including using organic farming techniques that was also one of the aims of FIVDB in 2000.

4. the rice-duck technology for FIVDB was an innovative method in its overall aim of promoting regenerative organic agricultural practice or technology.

Interview 2: **Dr. Shaikh Tanveer Hossain**, Ex BRRI Scientist, currently with FIVDB, Dhaka, 24 October 2013

During training on advanced agriculture in Japan in 1998, visited a rice-duck farmer who showed him and his colleague his farm and later a video of how the rice-duck method worked. The promotional video clearly 'showed the increase in rice tillering, root growth and yield, decrease in insects and weeds, and how the ducks soften the soil with their bill and feet movement'. Both were impressed and felt that the method would be workable in Bangladesh, and on their return convinced the DG of the Institute of its potential for the country. They were allowed to send a proposal to the PETRA project then being implemented by IRRI in Bangladesh.

As PETRA's mandate was to identify and support innovations aimed at 'increasing rice productivity', the potential of the rice-duck farming method to enhance rice yield was recognised. There followed lengthy process of identifying an implementation modality that was acceptable to both BRRI and PETRA/IRRI. 'Early in 2000, a first concept note developed by BRRI and submitted to PETRA was not approved. PETRA stressed that the institutional support was not in place for BRRI to make the model work, unless strategic partnerships were developed. When a new proposal was submitted in partnership with FIVDB as the leading institute in Bangladesh with duck expertise, the proposal was approved.'

In July 2001 the research in integrated ricr duck farming started in Sylhet for a three year period.

[STH left for PhD after two years]

Technical points

- Ducklings start foraging around 15 days after transplantation of seedlings
- Graze the fields initially for 2-4 hours for about a week
- Thereafter for longer period of time, for up to the flowering stage which about 45-60 days depending the paddy variety and season
- Irrigated land in winter: ducklings do not adjust to the cold water very well leading to higher mortality
- During rain fed season in monsoon: ducklings adjust well, gain weight quickly and lower mortality

Merits of the system

- It works better in low and irrigated land, where paddy seediling is transplanted in lines and spacing
- Ducks control insects and weeds, releases trapped nutrients by softening the soil with bill and feet movement and droppings

De-merits of the system

- Availability of ducklings may be a problem if a nearby hatchery is not present, then have to go far to collect day-old chicks (high mortality in transport)
- Ducks needs to be housed away from the field because of the small scale of operation, while large areas can create security for large number of ducks near the field
- Neighbouring farmers use chemicals that run off to duck fields posing hazards
- Problem with marketing of organic produce as there is no certification authority as well as lack of recognition of value of 'organic' food

Interview 3:**<u>Zahid Hossain</u>**, Director Livelihood Enhancement Programme, FIVDB, Sylhet, 20 February 2014

Was involved with the IRRI research from the perspective of livelihood enhancement, conducted economic analysis [can't remember much!] as part of which he visited China where farm sizes are large and the shelter in the field. <u>The ration of land-duck same as what being promoted by FIVDB</u>, for resource poor farmers with smaller land area.

There is rearing management problem particularly with predators, nursing of chicks and ducklings particularly in winter.

Econ analysis: found from pilot research, costs to decline by 30-50% while production increases by 10-15% compared with chemical management. Using family labour particularly women who are traditionally engaged in caring for small animals.

Programme implication: providing ducklings to the trainees as incentive, required large supply of ducklings. To overcome this promoted rice-husk based hatchery (Chinese method) at homestead level with mixed results: for the winter this was not very successful but in monsoon it was relatively better [then did what?]

Staff was given better orientation:

Ensure proper timing for release of ducklings on the field [not too young in winter?] such as:

- observe for availability of vegetation (for weed control),
- observe for harmful insects with pictorial cards showing charred leafs, damaged leafs, etc,
- if there's sufficient fertiliser in the field with charts developed by BRRI

Not yet very widely or visibly popularised because:

- small scale nature of the promoted technology;
- relative return to labour may be lower compared with rice alone.

However, local perception of ducks being an 'enemy of paddy plants' has changed, and awareness of benefits of organic food is increasing.

Interview 4:**<u>Malik Anwar Khan</u>**, Trainer, FIVDB, Sylhet, 20 February 2014.

After the research phase (2001-2004) when the participating farmers were trained and supervised by the research team, the training unit of FIVDB developed its own training module and the first batch of FIVDB beneficiaries were trained in 2006-2007 under a project supported by HKI. The module was revised in 2009 based on the training unit's own monitoring findings and feedback received from the field supervisors of FIVDB's programme division. Their field experiences led them to identify several issues that were either not observed during the research phase, became apparent with changing crop practices in the locality or to accommodate beneficiary preferences.

The following additional information were incorporated in the revised training module and manual for the trainers:

In order to reduce preventable mortality, in the chapter on duck diseases three new diseases were incorporated with advice on preventive and curative measures: chronic respiratory diseases (CRD) for adult ducks, paralysis in ducks of all ages, and E-Coli in chicks.

The revision introduced three specific feeds as supplements to crop field and home-made food with appropriate nutrients[8] for balanced feeding, namely, starter pellet, grower feed and layer feed. This was necessary because it was observed that there was a shortage of nutritious food which used to be available in the local water bodies, due to increasing use of chemicals in paddy fields as a result of expansion of dry season paddy using irrigated ground water.

The third change was brought about as a result of beneficiary practice of grazing mixed size ducks in the paddy field due to financial constraints. It was advised for them to change the distance in the lines and spacing for transplanting seedlings to 8inch by 8inch (from 6" by 8").

[8] It include five nutrients: protein, carbohydrate, fat, vitamins, and minerals

11.3 Annex: Case studies of interesting cases for pathways to adoption

Case study 1

Md. Abdur Muhibur Raman, age 42, Narayon Pasha Village, Moulavibazaar Sadar Upazila, Maulovibazar District. Being a member of Community Learning Centre (CLC) and having experience of homestead based duck rearing, he was selected for receiving training on the rice-duck farming technology by FIVDB a national NGO in 2010. Since his training, he has been using the rice-duck integrated farming method and has become one of the successful farmers in his area. Before his training he used to rear ducks (30-50) in the traditional way at nearby lowland, ponds and small rivers but after the first season's success with rice-duck farming Muhibur expanded his operation to unprecedented number of ducklings and land area. This makes him an interesting case.

After receiving training Muhibur Raman started to apply rice-duck technology in 0.25 acre of land with 50 ducklings in the first year. That year he reports that he benefited from using the technology, specifically he mentioned his paddy production was 120 kg more than the previous years of traditional farming, and he made a saving of BDT 1,000 or US$ 12.660 by not having to hire labour for weeding. In fact, the success of his first year inspired him to expand his operation in the near future.

In the following year (2012), Muhibur scaled up his operation to an incredible 500 ducklings on a plot of land of 7.50 acre most of which belonged to his neighbours. To manage such a large operation, he employed a person with a monthly salary of BDT 5,000 or US$ 63.301. One of the manager's tasks is to organise regular vaccination for 500 birds, from the Government Livestock Services Department based at Upazila (vaccines are produced and distributed by the Government alone).

He has currently become a fulltime rice-duck farmer from a traditional rice farmer and duck rearer. He reports that rice production using the technology increased by an estimated 20 % as a result of increased fertility of land, compared with traditional method. He estimates that with the technology we can save BDT 20 or US$ 0.253 per decimal of land [ha = 247 decimal]. An additional benefit is the second crop of duck eggs and meat that he can consume at home thus contributing to improving his family's protein intake and nutritional status, and sell them to earn cash income.

From his experience, he found that five ducks could be reared in each decimal of land during the last season in 2013. He also faced some problems in the management of ducks when paddy field is not prepared for duck rearing, during the dry season when water bodies become dry when he has take the ducks to open water-bodies, and shortage of vaccination in the livestock offices when he had to go to different, far flung upazila from his home.

When he first started using the technology, his neighbors were furious thinking that the ducks would ruin their paddy fields but currently they appreciate that the technology is very good in terms of higher production, low costs and good for land, animal and human health. Some neighbors come to him to learn the process, and some land owners invite him to rear ducks in their paddy fields; he also inspires them to apply the technology. Amongst them, Mr. Faruq Mia has learned the technology from him and has started rice-duck farming with 200 ducks on 0.50 acre of his own land. In fact, the social taboo that duck is always harmful for paddy is almost diminished in his area.

Case study 2

Interesting case -Md. Faruq Mia (Learned from Md. Abdul Muhibur Raman)

Md. Faruq Mia, age 33, East Narayon Pasha village, Moulavibazaar Sadar Upazila, Moulavibazaar District. He is a famous farmer in his village now. He is not a member of any FIVDB supported village group such as the Community Learning Centre (CLC) but has connections with the CLC members in village through whom he learnt about the RD technology. He has two big size ponds adjacent to his house and every year he cultivates fish of Tilapia, Mirror carp, Grass carp, Ruhi and Katla in these ponds. Her wife used to rear some ducks in traditional ways in those ponds for meeting family needs of eggs and meat. He took his experience of caring for fish in his pond to caring for ducklings that he learned from a trained adopter thus making him an interesting case.

Once he heard that Mr. Faruq's neighbor, Md. Abdur Muhibur Raman applied rice-duck technology in 2012 after receiving training from FIVDB. From then he had regular communications, visit and discussions with Mr. Rahman. He observed that Muhibur benefited from applying this technology in terms of increased yield of rice and made cost savings of BDT 5,000 or US$ 63.301 as he did not have to use chemical fertilizer and pesticide, of de-weed his field.

Muhibur's success with the technology inspired Faruq and he adopted the technology in his nearby 0.80 acre of land in consultation. Prior to starting his own operation he held hels several discussions with him. He bought 200 ducklings (10 days old) from the local bazaar and made a shelter for them. During the initial stages he followed the advice of Muhibur particularly on how to take of the ducklings explaining about the need for vaccination of and providing vitamins to the ducklings as well as drawing up a schedule for releasing them in the paddy field twice a day with a home break in mid-day. He expressed his gratitude to Muhibur for his advice, encouragement and regular visits to his house to see his progress.

His success during the first season of applying the technology earned him 350 kg of additional rice from 0.80 acre of land, and saved up to BDT 2,000 or US$ 25.320from not using chemical fertilizer and pesticides as well as not having to de-weed his field. After five and a half months, the ducks started to lay eggs and on an average they laid 50 eggs each round the year that increased his family income considerably.

He thinks, this experience of RD technology is very effective for the poor farmers. In the following year he continued with rice-duck farming with similar scale and benefits. Seeing their experiences, the neighbors are becoming interested in using the technology; he thinks that the misconception the social had regarding duck-rice cultivation ('ducks are enemies of rice') has nearly vanished.

Case study 3

Interesting case of Abdul Mannan Laskor [inspired and Taught by Jamila Begum]

Abdul Mannan Laskor, age 48, Baloramer Chak village, Kaskonokpur UP, Zakiganj sub-district of Sylhet district, Bangladesh. He is the Chairperson of Baloramer Chak CLC (Community Learning Center), facilitated by FIVDB, a national NGO. Being a leader of CLC he was aware of the training on RD technology and known that Jamila Begum, a member of CLC had been trained of the three-day course [24 hour training contact].

After Jamila started rice-duck farming, he was curious as to what it involved and how it worked thinking that "all my life I knew that ducks will damage young paddy plants". He decided to visit and observe Jamila applying the RD cultivation when she began it in early 2012. He found that rice grew more, there was no need to use chemical fertilizer and pesticide, nor was there any cost of weeding as a result of the technology; all these attracted him and he became more interested in learning about the process. In the second season, Mr. Laskor visited Jamila's field and observed the process keenly and also talked with Jamila about the different aspects of the technology, such as what do the ducks eat, why the young plants are not damaged, about the need for vaccination and so forth. Having learned and understood the process and seeing the higher yield of paddy he decided to apply the technology on his own land.

As he had previous experience of farming rice and rearing ducks in his backyard and learning the technology from Jamila, he made a plan to cultivate RD in his nearby 0.20 acre of land. He did not have the money for the initial investment, he informed his brother who lived abroad (a country of middle-east) about it and requested his brother to send some money (BDT 8,000 or US$ 101.281) so that he could to buy the required number of ducklings. After receiving the money from his brother, he bought 50 ducklings (two months aged) from the local bazaar.

In 2013 he started to apply the technology. From the very beginning, he consulted with Jamila for several times; Jamila also advised him and visited his field and home as and when possible. After completion of the first season's farming his benefits included about 115 kgs additional paddy, saved cost of fertilizer, pesticide and weeding that he estimated to be around BDT 800 or US$ 10.128. He also realized that the process made the land fertile, and produced crops and protein were healthier than the traditional method. He also had an additional crop of eggs and duck meat from the process. Lastly, he experienced that the appropriate age of ducks (one month more) worked better 20 days after plantations of seedlings in the paddy field.

As a result of his work and others, the people of his village became aware of the process and the benefits of the technology. Many of the other land owners invite Laskor to rear his ducks in their filed, i.e. the attitude of the local community toward ducks in paddy fields has changed completely over the last three years. Mr. Laskor is now planning to scale up the technology.

Case study 4

Interesting case of Duck-Rice combined cultivation [follower of Mina Begum]

Farzar Ali, age 43, North Ghaterchoti Village, Chiknagole Union, Jaintapur Upazila of Sylhet district. He never attended school and he does not own any cultivable land. He learnt about the duck-rice technology from his neighbor, Ms Mina Begum who had received training from FIVDB (a national NGO in Bangladesh) three yours ago.

Three years ago, seeing the duck rearing in rice field by Mina, Fazar Ali observed the process keenly, and he was particularly interested because he knew that Mina was trained by FIVDB that he thought to be pro-poor organisation. His family had also good experiences with FIVDB; after his wife was trained on operation of mini duck hatchery () he worked his wife on the hatchery that contributed substantial proportion of their family earnings. They sold chicks and ducklings produced from their own hatchery.

After watching Mina Begum operating and benefiting from the ricr-duck farming method he decided to apply the technology himself. He was especially encouraged by the fact that there were two crops to be grown on the same field as rice and ducklings were farmed in tandem, there was no need for chemical fertilizer, pesticide and weeding that eventually saved good amount of production cost. He thought the rice grown with the technology was healthier (*"shashtho-shommoto"*) and *"shadeo bhalo"* or "tastes better".

It is worth mentioning that Fazar Ali before taking up rice-duck farming used to rear some ducks (8/10) for meeting household needs (consume at home and sell when needed).

Fazar Ali's introduction to rice-duck farming was made when Mina Begum who is one of his close-by neighbour, invited some of her neighbors to release their ducks in her extended field (150 decimals) in the second season (in same year of 2011). Fazar Ali agreed to rear his 10 ducks on Mina's rice field and he observed the process more intensively and felt encouraged to use the technology himself. Besides, he consulted with Mina about the process in detail making several visits to her plot and her house.

As part of rice-duck cultivation planning, Fazar Ali, took lease of some land (0.22 acre) for BDT 1,400 or US$ 17.724 a year and reared 40 ducks in 2012. From then, he has been rearing 40 to 45 ducks every year. Besides the learning from Mina, the leased land near by his house, support from his wife and son made it possible for him succeed.

He described the benefits of the combined cultivation of each season as: i) grew more rice (5,000 kg) than traditional rice production in the land, ii) did not have to buy or use chemical fertilizer and pesticide, and there was no need for weeding, which saved around BDT 2,000 or US$

25.320 that would have otherwise been needed, iii) ducks became healthier (started laying eggs about a month earlier than the traditionally raised ones), iv) land became more fertile, v) earned an extra crop of eggs that in the last year (2013) was worth BDT 14,400 or US$ 182.305 (form 1800 pieces at BDT 8 or US$ 0.101). Additionally, he could use the eggs in their duck hatchery which made it easier for him and his wife to find appropriate fertile eggs from outside sources (the outside eggs sometimes were infertile).

He is thinking of scaling up his integrated duck-rice cultivation in the next season. He estimates that if he could use 0.60 acre of land to rear 120 ducklings, he would be able to meet all his family expenses from this enterprise. He also added that the neighbours no longer had the misconception of ducklings would damage rice plant. Some of his neighbouring land owners invited him to rear his ducks on their fields in the last season (2013).

Case study 5

Interesting Case: Jamila Begum [teacher of Laskor]

Jamila Begum, age 40, of Boloramer Chak village, Kaskanakpur Uion, Zakiganj Upazila (sub district) of Sylhet district, Bangladesh. She is illiterate and her family does not own any cultivable land while her husband has speech and hearing disability so he cannot work like other agricultural labourers. She has five children and two of them are grown up.

She was trained on rice-duck farming course in 2011 by FIVDB, a national level NGO. Being a member of her village Community Learning Center (CLC – supported bu FIVDB) and her experience of rearing duck on her backyard, she was selected for the course by CLC management committee. Before her training she used to rear duck in her backyard but did not know “how to properly take care of them . . . about feeding such as boiled vegetables or fish entrails and scales, vaccinations, keeping the chicks warm, etc”.

Since her training, she has undertaken rice-duck farming for four cycles in the last two years (during monsoon and winter dry seasons). She cultivated in a nearby leased land of 16 decimals and she reared 20 ducks on an average each cycle (ranging from 18 to 30 ducklings). She had 18 ducks at the time of this interview (February 2014).

She reports to have benefited from the RD cultivation. She her rice production was nearly double compared with the traditional method, of 200 kg compared with 115 from the same size of land.

Her duck were also healthier as they started laying eggs a month earlier than traditional rearing method. She did not need any use of chemical fertilizer and pesticide; she did not even need de-weeding her paddy field. She estimates that rice-duck farming had saved her around BDT 500 or US$ 6.330 each season.

From the very beginning of her applying the technology the CLC chairperson, Abdul Mannan Laskor was very curious about the process though many other neighbors were very negative about it holding the conventional view. The main reason for their reservation was that people thought that ducks would damage the paddy plants ("eat them up"). People used to ask her if she was okay or if there is something wrong with her, while she used to take the chicks to the paddy field twice a day and remain there for thre to four hours keeping an eye out for predators (large birds, mongoose, etc) and for her ducklings do not stray on to other paddy fields.

She has used the technology just as she was trained to except that she uses ash from her cooking stove in the paddy field as organic fertilizer.

Mr. Laskor on the other hand was visiting her plot frequently to see what she was doing, and after a while started asking Jamila questions about the technology. She said, " he would ask me how does the ducks help and I would say they are my labourers taking care of the weeds and loosening the ground for the paddy to grow stronger". She thinks he talked with her "at least five times", as well as observing keenly what she was doing in the field during the first season. She also told him about the doubling of paddy production compared with previous year (231 kg instead of 115kg from 0.16 acre of land).

In the following year, in 2013 Jamila heard that Laskor has started to apply the technology in a small scale (50 ducks in 20 decimals land). Her visited her to tell her her that using the technology his paddy production was better than before (traditional method) but Jamila could not recall the exact amount of Laskor's production level.

On her own plans for the next season (early 2014) she has spoken with a neighbouring landlord for taking out a lease on a further eight decimals of land to expand her production to 0.24 acres for paddy production with duck. There is little doubt about the sustainability of the integrated rice-duck farming at micro level when the farm's manager is a woman named Ms. Jamila Begum who has also inspired her sister to adopt the technology.

Case study 6

Interesting case of Mannan Mia, Bangshidhar [teacher of Aamir Ali]

Mannan Mia, age 55, Bangshidhar village, Kadhimpara Uion, Sylhet Sadar Upazila of Sylhet district, Bangladesh, is a farmer who received training on integrated rice-duck farming from FIVDB in 2009. He was also the Chair of Community Learning Centre (CLC) in his village supported by FIVDB. Initially he received training in organic vegetable cultivation but have not applied his knowledge himself but taught his brother who continues it on a commercial basis (he did not elaborate the reasons for not adopting the organic vegetable growing technology).

After receiving the training, he cultivated rice-duck for two years in both of the paddy cultivating seasons (monsoon and winter). He got benefits from the technology in terms of more crops, the ducks ate the weeds which made the weeding cost zero, there was no need for the use of chemical fertilizers and pesticides which made the land healthy as well as the production of rice, eggs and meats were also good for human health.

He discontinued with the rice-duck technology as there were not enough people in his family to help him particularly with nursing of the chicks and ducklings. In addition, which appears to be a more realistic reason for discontinuation, he found the income from the small scale was not adequate to cover his family expenses if he himself was engaged full time with the technology. He also added that he could not scale up his operation due to lack of cash capital and land. He however estimates that if someone could cultivate 100 ducks in 3.00 acre of land, it would pay for the living expenses of a family of five or six members.

While he was farming rice and duck together, many people observed the process though initially most of them became surprised and skeptical thinking that the ducks would destroy the paddy plants. Seeing his experience of the first season some of his neighbours became interested in learning about the process. Amongst them Babul Mia, Sadik Mia and Amir Ali were specifically interested and who spent time with Mannan Mia to carefully learn the technology in the second season.

They often used to visit and observe the process and talk with Mannan Mia who facilitated their learning process (he thought it was his duty as he was the Chair of the village CLC). In the third season, Amir Ali started to use the technology and took advice from Mannan Mia on a regular basis which was helped by them both living in the same village and knowing each other since their childhood. Mannan Mia often visited Aamir Ali’s field on the latter’s request and provided advice and encouragement (he thinks he had visited Aamir’s farm at least on four occasions during the season. Mannan proudly noted that Aamir is currently a full time duck-rice farmer and meets all his family expenses from the technology.

Even though he does not use the technology himself but thinks that because of the two years when reared ducks in paddy fields around 50-60 families in his village are aware of the benefits of the technology. The local farmers have changed their thinking about ducklings being harmful for young paddy plants and many casually release ducklings in their fields. They also invite household level duck farmers (who rear 5-10 ducks) to rear ducks in their paddy fields.

Case study 7

Interesting Case of Mina Begum (taught by Fazar Ali)

Ms Mina Begum, age 45, North Ghaterchati village, Chiknagul Uion, Jaintapur Upazila of Sylhet district, Bangladesh. She received her training on rice-duck farming in 2011 when FIVDB offered the training to her village group – Community Learning Centre (CLC) as part of their livelihood enhancement programme for the CLC members. since her training she has applied the technology once a year for three years.

Mina is an innovator and risk taker, who after applying the technology as per the prescribed model of 30 ducklings on 0.15 acre of land soon after her training in 2011, felt that she could scale up her operation the following paddy growing season (later in the same year). She was encouraged by the results of her first attempt at applying the technology that included higher yield than the traditional method, and her expenses and effort were reduced as she did not have to use any hired or family labour for weeding nor any fertilizer or pesticide and herbicide (she used the Bangla term *bish* meaning poison).

Being a neighbor, Fazar Ali keenly observed the process and gradually became interested in the technology.

For scaling up her operation she needed both additional land ducklings. While her family (husband) owned 1.50 acre of land suitable for paddy farming but she lacked the financial resources to purchase the required number of ducklings. With the support of her husband she could raise funds for a total of 50 ducklings that would not be effective for rice production on her plot. She thought of the idea that she could invite her nearby neighbours to send their ducklings to her paddy field where the ducklings can feed themselves and reduce the cost of buying additional feed for them. Mina said, "*eta korey shobai labhoban hobey*" ("by doing this everyone benefits/profits").

She motivated 4/5 neighbours to take part in what essentially was an innovative approach as well as risky move on her part, for scaling up her operation. Her neighbours were less of risk takers compared with her as they contributed 50 ducklings. She used these 100 ducklings in the second year of operation. One of her neighbours, Mr. Fazar Ali she thought showed more interest in the operation of the technology as he often visited her and discussed how the technology worked. Mina remembered that at the time of withdrawing the ducks from the paddy field Fazar Ali expressed interest in adopting the technology himself the following season.

She learnt that Fazar Ali had taken lease of a piece of land and bought ducklings to start his own operation of integrated rice-duck farming, with the help of his wife and son.

Mina shared that when she started the technology, people were very skeptical thinking that ducks would ruin the paddy plants but today the villagers are positive towards the rice-duck technology.

Case study 8

KII with Faruq Ahmed, Extension Agent.

Faruq Ahmed, a responsible staff of rice-duck intervention of FIVDB in Zakiganj upazila (Team Leader, Livelihood Enhancement Program-LEP) who was tasked to provide technical support to the RD farmers. He was trained on RD method by FIVDB's Training Division. The present interview was taken with regards to understand the technical assistance provided by him, especially for the farmers of Madarkhal village where Mr. Aminul and Mr. Abdulla (the former a special case and the latter his follower) cultivated RD and became successful.

In the answer to the question regarding what kind of technical support he provided to the farmers he said that he had to provide more intensive support and monitor the RD cultivation; he visited at least once a week, sometimes twice during the first season following training of the farmers. He described the technical supports he provided as follows:

i) He motivated the trained farmers to erect fencing around the paddy filed so that the ducks did not stray on to other fields or not attacked by predator birds or animals and were habituated in the selected RD field;
ii) Ensure that the farmers did not keep the ducklings too long at a time in the field; twice a day for two hours each time with a break at noon because water would become hot and cause sickness to the ducklings;
iii) Motivated the farmers not to use chemical fertilizer, pesticide, insecticide or herbicide;
iv) Motivated them to vaccinate the ducks on on the required basis;
v) Developed linkage between the livestock and agriculture extension offices of the government at upazila level and the farmers, whereby the latter could seek support for vaccination and technical advice;
vi) Assisted the farmers to keep written account of the benefits such as gain from zero chemical fertilizer and pesticides, without weeding, parallel duck and eggs production and more rice production that attracted them in RD technology;
vii) Provided motivation in other alternative organic crops like homestead vegetable cultivation as supplementary income source.

In the answer regarding the question of what kind of problems the farmers faced and sought support from his office, he mentioned two aspects mainly; one is the diseases of ducklings and the other is the diseases of paddy plant.

In the answer to another question regarding whether the negative attitude towards integrated RD farming has been changed, he mentioned that after the first season's demonstration the traditional views held by the community started to change gradually. In the first season the neighbors observed the technology with curiosity and some disbelief when the ducks were allowed on to the paddy fields, what the ducks did, how the plants became visibly healthy, why there was no need of weeding etc. The neighbors later admitted that their idea was wrong but they learnt that the ducklings/ ducks had to be released on to the fields 15/20 days after transplantations up to the point when flowering began, which was critical to understand the technology and to change their traditional ideas about ducklings destroying young paddy plants.

Finally, he was asked if he had any recommendations based on his field experience of working with the rice-duck farmers. He recommended the following:

- The input support needs to be increased specially the number of ducklings (at least 50 instead of 30) in order to compensate for mortality;
- The training and support should be given in a cluster basis, i.e. to groups of farmers from one area; so that they can share ideas and seek support from FIVDB and GoB offices as groups. It might inspire the farmers to cooperate among themselves on technical and commercial aspects of the operation;
- The ratio of duck and land may be changed as he had observed some farmers to successfully rear up to four ducks per 0.15 acre of land (compared with the prescribed ratio of two ducklings per 0.15 acre of land);
- There is a need for close monitoring of and technical support provision for the farmers, particularly during the initial months of RD technology application.

11.4 Annex: Survey results

Table 41: Problems with traditional methods

Problems identified	Identified by	
	Number	Percent
Did not understand problems in the past	25	31.3
Low paddy production/low yield	21	26.3
Need to use chemical fertilizer & insecticide	20	25.0
Frequent insect attacks	19	23.8
Wage labour needed	19	23.8
Frequent illness of ducks	15	18.8
High labour intensity	14	17.5
Low prices for ducks	13	16.3
Need to use insecticide	11	13.8
More food needed for ducks	8	10.0
Low production of eggs	6	7.5
Diseases killed ducks	4	5.0
Ducks went missing	4	5.0
Frequent quarrel with neighbours	3	3.8
Impure seeds and chemical fertilizer	1	1.3

Table 42: Objectives of adopting the technology

Identified objectives	Identified by	
	Number	Percent
Rice production increase	73	91.3
Less expenses as do not need to buy fertilizer, duck food, weeding labour	32	40.0
Use organic fertilizer instead of chemical fertilizer	26	32.5
No need for insecticide	23	28.8
Avail eggs	21	26.3
Grow organic food as chemical fertilizer is harmful	21	26.3
Earn more profit by selling ducks and eggs, extra income	21	26.3
Duck waste becomes organic fertilizer	17	21.3
Ducks work as weeder/labour	13	16.3
Duck production increase	12	15.0
Ducks feed on insects	12	15.0
Gain meat	12	15.0
Less labour/less time	6	7.5
Ducks feed on weeds	6	7.5
Get money for children expenses by selling eggs	2	2.5
Get free chicks [after training]	2	2.5
To conduct new experiments	3	3.8
Children could have eggs	1	1.3

Table 43: Distribution of responses on how rice-duck farming is different from previous practices

Identified Differences	Identified by	
	Number	Percent
Increased rice production	38	47.5
No/less chemical fertilizer	36	45.0
No need for insecticide	36	45.0
No need for weeding	34	42.5
Use organic fertilizer	30	37.5
Less/no spending on weeding and insecticide	24	30.0
Less feeding of ducks	16	20.0
More eggs produced	15	18.8
Less/no spending on chemical fertilizer	12	15.0
Less labor and effort	11	13.8
Paddy plants grow strong	10	12.5
No Labor cost, duck work as labor	6	7.5
Needs fencing the plot	4	5.0
Did not know duck raring earlier	2	2.5
No difference observed	2	2.5
Needs vaccination of ducks	1	1.3

Table 44: Inputs used, source and place of purchase

Input	Identified by		Source		Place of purchase	
	Number	Percent	Own, etc	Purchased	Inside village	Outside village
Chicks	78	97.5	(49[1])	23	2	21
Land tilling	63	78.8	26	37	8	29
Seed	59	73.8	37	22	2	20
Seedling	57	71.3	43	14	4	10
Bamboo	55	68.8	32	23	5	18
Net (synthetic, for fencing the plot)	52	65.0	2	50	1	49
Compost	45	56.3	40	4	-	4
Duck Food	36	31.3	-	36	-	36
Wood	23	28.8	7	16	-	16
Broken rice	22	27.5	11	11	4	7
Duck Shelter	21	26.3	19	1	1	1
Cow dung	20	25.0	19	1	1	-
Water/irrigation	18	22.5	12	6	4	3
Wire-nail	18	22.5	-	18	-	18
Covering	13	16.3	13	-	-	-
Rice bran	57	71.3	29	28	5	23
Corrugated Iron Sheet (Tin)	12	15.0	3	9	-	9
Urea fertilizer	10	12.5	-	10	-	10
Rice husk	9	11.3	1	8	1	7
Vaccine	8	10.0	-	8	-	8
Saline	8	10.0	-	8	1	7
Water hyacinth	7	8.8	7	-	-	-
Medicine	7	8.8	-	7	-	7
Bamboo Post	4	5.0	3	1	-	1
Duck dropping	4	5.0	2	2	2	-
Sac (jute)	3	3.8	-	3	-	3
Bamboo Fence	3	3.8	-	3	-	3
Oil Cake	2	2.5	-	2	-	2
Wire/string/rope	2	2.5	-	2	-	2
Wild vegetable	1	1.3	1	-	-	-
Earth worm	1	1.3	1	-	-	-
Goat dropping	1	1.3	1	-	-	-
Pesticide	1	1.3	1	-	-	-
Brick	1	1.3	1	-	-	-
Polythene	1	1.3	1	-	-	-
Labour (wage)	1	1.3	-	1	-	1

Table 45: Financial analysis (BDT per hectare/year)#####

Farmers and method	Gross return	Variable cost	Gross margin	Total cost	Income net
Rice-duck technology					
All adopters[1]	182,498 (US$ 2,310.44)	91,215 (US$ 1,154.79	91,282 (US$ 1,55.64)	96,222 (US$ 1,218.18)	86,276 (US$ 1,092.26)
Female adopters	174,177 (US$ 2,205.10)	89,779 (US$ 1,136.61)	84,398 (US$ 1,068.49)	92,532 (US$ 1,171.46)	81,644 (US$ 1,033.62)
Male adopters	191,694 (US$ 2,426.87)	92,803 (US$ 1,174.90)	98,891 (US$ 1,251.97)	100,299 (US$ 1,269.80)	91,395 (US$ 1,157.07)
Comparator					
Pilot farmers (2004 data in 2013 prices)	130,455 (US$ 1,651.57)	60,211 (US$ 762.277)	70,244 (US$ 889.296)		

Table 46: Inputs used in rice cultivation

Response	Responded by	
	Frequency	Percent
Seed	23	62.2
Ploughing	22	59.5
Urea fertilizer	22	59.5
Insecticide	19	51.4
Water/irrigation	18	48.6
Land	15	40.5
Seedling	13	35.1
Cowdung	5	13.5
Medicine	5	13.5
Labour (wage)	4	10.8
Compost	3	8.1

Table 47: Reported inputs needed for duck rearing

Response	Responded by	
	Frequency	Percent
Duck Shelter	18	48.6
Rice bran	15	40.5
Poultry Feed	11	29.7
Covering	9	24.3
Medicine	8	21.6
Broken rice	7	18.9
Chicks	7	18.9
Rice husk	3	8.1
Vaccine	2	5.4
Bamboo Fence (for shelter)	2	5.4
Sac	1	2.7

Table 48: Reasons for initially adopting RD

Response (reasons)	Responded by	
	Frequency	Percent
Rice production increase	31	83.8
Lower expenses (no need to buy fertilizer, duck food, wage labour)	15	40.5
More profitable by selling ducks and eggs, extra income	13	35.1
Gain eggs	12	32.4
Gain meat	9	24.3
Ducks feed on weeds	8	21.6
No need for insecticide	8	21.6
Free chicks from FIVDB	5	13.5
Use organic fertilizer instead of chemical fertilizer	4	10.8
Ducks eat insects	4	10.8
Duck production increase	3	8.1
Get organic food (chemical fertilizer is harmful)	3	8.1
Meet children's expenses with sale of eggs	2	5.4
Ducks work as weeder/ labourer	1	2.7
Children could eat eggs	1	2.7
Less labour/ less time	1	2.7

Table 49: Experience of duck raising and rice growing

Response	Responded by	
	Frequency	Percent
Cultivated rice before hearing about the rice-duck technology	17	89.5
Reared duck before hearing about the rice-duck technology	16	84.2
Currently cultivate/produce rice	16	84.2
Currently rear/produce duck	13	68.4

Table 50: Inputs used for rice cultivation

Response	Responded by	
	Frequency	Percent
Land	14	73.7
Urea fertilizer	14	73.7
Ploughing	13	68.4
Seed	12	63.2
Medicine	9	47.4
Insecticide	9	47.4
Seedling	9	47.4
Water/irrigation	6	31.6
Labour (wage)	5	26.3
Compost	2	10.5

Table 51: Practice of rice cultivation

Response	Responded by	
	Frequency	Percent
Ownership of lands		
Self Owned	4	21.1
Rented	6	31.6
Both of above	7	36.8
Inputs used		
Insecticide	17	89.5
Chemical fertilizer	16	84.2
Weeding	9	47.4
Cow dung and compost	2	10.5
Irrigation	1	5.3
Transplant into Lines	1	5.3

Table 52: Inputs needed for duck rearing

Response	Responded by	
	Frequency	Percent
Duck Shelter	12	63.2
Chicks	10	52.6
Rice bran	10	52.6
Covering	7	36.8
Poultry Feed	5	26.3
Bamboo	4	21.1
Broken rice	4	21.1
Bamboo Fence	3	15.8
Snail	2	10.5
Medicine	1	5.3

Table 53: Source and year of training

Source and year	Frequency	Percent
Source of technical knowledge		
FIVDB training	15	79.0
Neighbour/relatives	4	21.0
Year		
2010	9	47.4
2011	2	10.5
2012	1	5.3
2013	6	31.6
Don't Know	1	5.3
Total	19	100.00

Table 54: Difficulties faced with traditional system of rice cultivation

Response	Response by	
	Frequency	**Percent**
Insect infestation	7	36.8
Weed infestation	6	31.6
More insecticide needed	5	26.3
High costs of chemical fertilizer/weeding/insecticide	4	21.1
Low yield	4	21.1
Natural calamity	3	15.8
High labour costs	2	10.5

Table 55: Difficulties faced with traditional system of rearing ducks

Response	Response by	
	Frequency	**Percent**
Frequent quarrel with neighbours	7	36.8
More food needed for ducks	4	21.1
Deaths caused by diseases	4	21.1
Ducks are lost/go missing	3	15.8
Ducks were frequently ill	3	15.8
Less production of eggs	1	5.3
Labour intensive	1	5.3

Table 56: Objection to Duck rearing from the neighbours

Response	Responded by	
	Frequency	Percent
Objection about rice rearing (no)	19	100
Objection about duck rearing (yes)	9	47.4
Specific objections		
If goes other's field it causes quarrel	5	26.3
Ducks will harm paddy field	2	10.5
Sometimes it becomes impossible to get the ducks back	2	10.5
Ducks eat fish of the pond	1	5.3
To get them back has to pay penalty	1	5.3

Table 57: Willingness and conditions for using the technology in future

Response	Responded by	
	Frequency	Percent
Respondent is interested in rice-duck farming in future (yes)	16	84
Conditions		
Availability of loan	12	63.2
Training support needed	8	42.1
Supply of duckling free of cost	6	31.6
If can take lease of land	2	10.5
Support of medicine and vaccine facility	1	5.3
If there is a facility of rearing ducks in dry season	1	5.3