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Inputs Used in Modern Variety（MV）Paddy Farming and Household Income : A Comparative Study of Rice-prawn Gher and Year-round MV Paddy Farming System in Bangladesh

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Summary

The present study attempts to examine the main inputs used in terms of volume and costs, such as irrigation, chemical fertilizers, pesticides and land plowing, for MV paddy production in rice-prawn and year-round MV paddy farming systems in Bangladesh. The study also aims to estimate the farmers' household income per capita and compare it with the average household income per capita among the people of Bangladesh. Ninety rice-prawn gher farmers from the village of Bilpabla in the Khulna district, and 100 year-round MV paddy farmers from the village of Chanchra in the Jessore district were randomly selected. The findings indicate that relatively less chemical fertilizers are used per unit in MV paddy production compared with the year-round MV paddy production. Similarly, the per unit irrigation costs and land plowing costs were also lower in MV paddy production under the rice-prawn gher farming system compared with the year-round MV paddy farming in Bangladesh. Even though the per unit yields of MV paddy under the gher farming system was higher in comparison with the year-round MV paddy farming. The gher farming system has also created a demand for more labor, both for temporarily hired workers and family members. Farmers in the rice-prawn gher-farming village have gained more agricultural income as well as household income compared with those of the year-round MV paddy farming system in Bangladesh. Thus it could be concluded that the technologically advanced rice-prawn gher farming system is a more factor-intensive farming system compared with the year-round MV paddy farming in Bangladesh.

1. Introduction

The rice-prawn gher-farming system is an indigenous technology solely developed by farmers since the mid 1980s in southwest Bangladesh. The term *rice-prawn gher* refers to the modification of a paddy field that has been used for prawn and paddy cultivation. The central field（locally known as *Chatal*）of *gher* is surrounded by high, wide dikes and canals that line the periphery of the dikes. The whole field of *gher* is filled up with rainwater from June to December, and resembles a pond. During this time, farmers cultivate prawn（*Macrobrachium rosenbergii*）and fish（*Catla catla; Labeo rohita; Cirrhina mrigala; Cyprinus carpio; Puntius sarana; Pungasias pangasias,* etc）. The entire land, except the canals, becomes naturally dry from January to April. The canals retain sufficient water［to cultivate］an MV *boro* paddy during this time. As a result, farmers can

grow an MV *boro* paddy in the *chatal*.

Before the introduction of rice-prawn gher farming, the southwestern parts of Bangladesh (mainly the Greater Khulna district (see figure 1) and southern part of the Jessore district) experienced a period of severe environmental change during the 1960s and 1980s. Many people in these regions blamed the construction of embankments and polders during the 1960s for the resulting environmental problems: water logging; restricted floodplain inundation with associated reductions in soil fertility; subsidence of land within the polders; siltation of rivers and canals; and increased saline intrusion. Moreover, some seasonal *beels* (swampland is locally known as *beel*) and low-lying areas became permanently water logged after the construction of such embankments and polders. The embankments were designed to limit saline intrusion in order to increase the amount of land for cultivation. But the resulting environmental problems created severe constraints on agricultural production and also disrupted the natural floodplain dynamics and increased the saline intrusion in some areas. A large amount of farmland was rendered agriculturally unproductive due to saline water intrusion and water logging in the Fakirhat and Chitalmari Thana areas of the Bagerhat district. As a result, people in these areas suffered from increasing of poverty and food shortages.

During the crisis period, people used to eat food from the wild, like *shapla* (water lily) and its seeds, for survival. Most of the people in the rural areas were unemployed, and people started migrating to big cities to look for work. At the same time, a few ambitious farmers in Fakirhat Thana in the Bagerhat district began to experiment with the cultivation of giant freshwater prawns (*Macrobrachium rosenbergii*). These farmers obtained good results in terms of growth, and the neighboring farmers gradually adopted the practice. After the introduction of export markets, the local farmers gradually started to convert their low-lying lands into gher for prawn cultivation. In the 1990s, the adoption of gher farming had increased dramatically, simply because farmers saw their neighbors making lots of money from gher farming. The gher-farming technology then quickly spread to the neighboring Thanas and districts, and the so-called gher revolution began (Kendrick [24]).

The landholding patterns, cropping patterns, and land tenant system changed after the introduction of rice-prawn gher farming in southwest Bangladesh in the late 1980s. There are some research works that have focused on benefit-cost analysis of rice-prawn gher farming, and the environmental and ecological impact of shrimp gher farming (Abedin and Kabir [1]; Abedin, Sarker and Hena [2]; Alim et al. [4]; Asaduzamman et al. [5]; Bhattacharya et al. [15]; Habib [19]; Nijera Kori [26]; Nabi et al. [25]; Rahman et al. [28]; Datta [16]; and Sobhan [33]). The rice-prawn gher farming system has significant impact on household income (Barmon et al. [9], [10], [11]) and labor demand (Barmon et al. [12]) compared with MV paddy farming. This farming has diffused rapidly (Barmon et al. [6]; and [8]) and the land tenure arrangement has changed from a traditional sharecropping system to a fixed cash rent system, and land ownership has also changed for the farmers (Barmon [13]). The marginal and poor farmers bought some farmland after the successful operation of gher farming (Barmon, et al. [7]). However, the main inputs used in MV paddy production under rice-prawn gher farming and the year-round MV paddy production have received less attention. Moreover, Barmon et al. ([9], [10]) estimated only household income. Therefore, this study compares the inputs' usage in MV *boro* paddy production under these two farming systems. This study also estimates the household income per capita com-

pared with rural people of Bangladesh.

This research paper is organized into eight sections. Following the introduction, farm surveys and data collection, and analysis methods are discussed in the methodology section. The gher crops and management, and paddy farming system are briefly discussed in section three, whereas inputs used in MV *boro* paddy production under the two farming systems are briefly discussed in section four. Section five explains the main input and output price of prawn and MV paddy production, whereas the labor input used in the two farming systems is presented in section six. A detailed comparison of agricultural and household income between the two agricultural systems has been made in section seven. Finally, conclusions are drawn based on the results and discussions.

2. Methodology of the Study

2. 1 Data Sources and Farm Surveys

The data used in this study were collected in two contrasting villages: Bilpabla in the Khulna district in the case of rice-prawn gher farming, and Chanchra in the Jessore district in the case of year-round MV paddy farming. Farmers in Bilpabla have vast experience in the rice-prawn gher farming system, like those in other gher farming villages in the Khulna district. On the other hand, farmers in Chanchra produce MV *boro* and MV *aman* paddies throughout the year. A sample of 90 rice-prawn gher farmers from Bilpabla and 100 year-round MV paddy farmers from Chanchra were randomly selected and interviewed to obtain necessary input and output data for the 2005 agricultural year. Jessore is a neighboring district of the Khulna district, and the villages of Chanchra and Bilpabla are approximately 60 Km apart. The altitude of paddy fields in Chanchra is slightly higher than the land for the gher farming in Bilpabla. As a result, the farmers in Chanchra cannot convert their paddy fields into gher farms. The two study villages are located as in figure 1.

This study describes the main inputs used in MV paddy production under the rice-prawn gher farming and year-round MV paddy farming systems. To see the cost and efficiency of the inputs' use, the present study also describes the cost of input used in MV *boro* paddy production under the rice-prawn gher farming system and year-round MV *boro* and *aman* paddy production. Labor is also an important input for any production system and significantly contributes to crop yield as well as the household income. As a result, labor input used in the two farming systems will be also discussed. Based on the final estimation of household income of the two farming systems, the household income per capita is estimated in a bid to show the economic gain from the gher farming system.

2. 2 Farm Size

Summary statistics of the farm sizes of the sampled farmers involved in the rice-prawn gher and year-round MV paddy farming is presented in Table 1. The table shows that the average rice-prawn gher farm was 4.09 *bigha,* and that the size varied from 1.0 *bigha* to 21.0 *bigha.* The average paddy farm size of the Chanchra area was 3.14 *bigha,* with a range of 0.66 to 15.18 *bigha.* In Bilpabla the average size was 2.52 *bigha,* with a range of 0.50 to 15.0 *bigha.* Generally, in Bilpabla it can be assumed that about 50 to 70% of rice-prawn gher farmland is used for MV paddy production.

3. Cropping Patterns of the Study Villages

Currently three types of paddy are being produced in Bangladesh in three distinct seasons: *aus* (April to August), transplanting *aman* (T. *aman*) (August to December), and *boro* (January to April). Among them, *aus* and T. *aman* paddies are produced in rain-fed water, and MV *boro* paddy is produced in irrigated

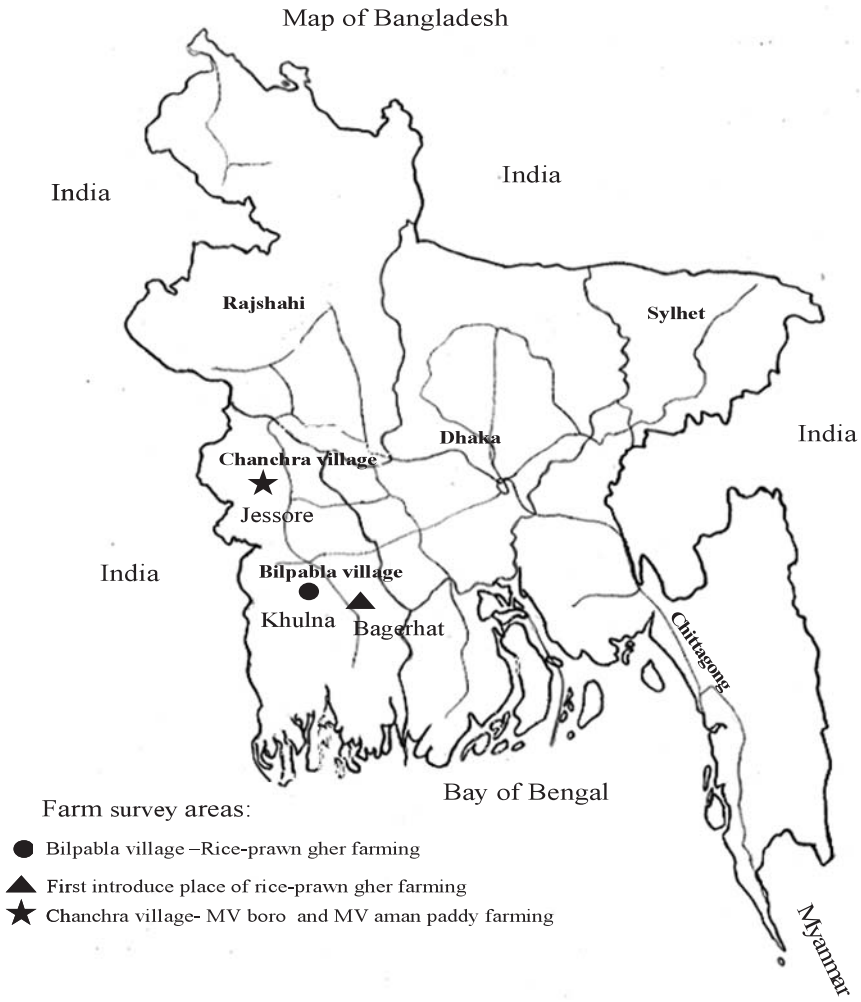


Figure 1. Study area

Table 1. Statistics of rice-prawn gher and year-round MV paddy farming

Farming systems	Mean	Max	Min	SD
Rice-prawn gher farming				
Gher area (*bigha*)	4.09	21.00	1.00	3.23
Paddy production area (*bigha*)	2.52	0.50	15.00	2.12
Year-round MV paddy farming				
MV *boro* paddy field (*bigha*)	3.14	15.18	0.66	2.63
MV *aman* paddy field (*bigha*)	3.14	15.18	0.66	2.63

Source : Field survey, 2006.
Note : One *bigha* is equal to 0.5 acres or 0.2024 ha in the locality.

water (ground water or rivers and canals). Modern varieties were introduced in Bangladesh for the *boro* and *aus* season in 1967 and *aman* season in 1970 (Hossain et al. [21]). In 2002, only 32% of the area was irrigated under MV paddy production in Bangladesh, (BBS [14]). Irrigation and chemical fertilizers are not used in local *aus* and T. *aman* production because the paddy fields are submerged. Farmers transplant MV *boro* paddy from mid-January to mid-February, and harvest from mid-April to mid-May. Farmers usually use chemical fertilizers, pesticides, and irrigation for *boro* paddy production. Along with paddy crops, farmers also cultivate oil seeds, potatoes, and vegetables in the comparatively high land during the winter season.

The cropping pattern of the study villages is presented in figure 2. Before the advent of gher farming in Bilpabla, the farmers cultivated only local *aus,* broadcasting *aus* and *aman* paddies in swampland, and transplanting *aman* (T. *aman*) paddies in the upper lands. The familiar broadcasting *aus* and *aman* paddies have almost disappeared mainly because of siltation of inland rivers and canals, embankment of rivers, and environmental changes. Oil seed crops such as rape, mustard and sesame were also produced in the comparatively high-altitude land located on the riverside. The life cycle of broadcasting *aman* is longer than that of broadcasting *aus* paddy, though the sowing time is same for both types. The sowing time of *aus* and *aman* paddy is in April / May; harvesting of broadcasting *aus* takes place in August, while harvesting of broadcasting *aman* takes place in December. The farmer sows *aus* and *aman* seeds together in April / May because after June / July the whole area is submerged under water due to heavy rain, and at that time it is not possible to transplant *aman* (*T. Aman*). This system of producing local *aus* and floating *aman* paddies together is known locally as *"Do-muti"*.

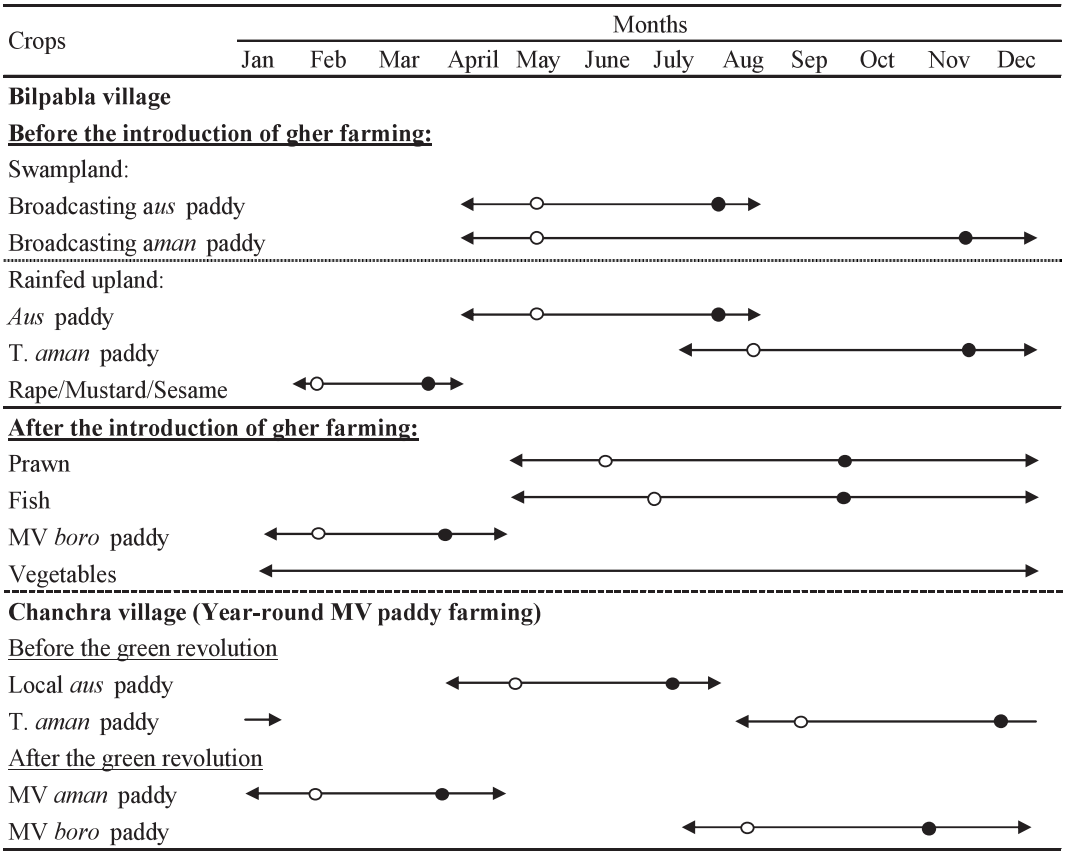
The gher farming system has dramatically changed the cropping patterns in the study area (figure 2). The construction of rice-prawn gher farming has created opportunities for crop diversification. Along with prawn and fish, farmers can now cultivate MV *boro* paddies in the central field and vegetables on the dikes of the gher, mainly for home consumption. Prior to the gher farming, farmers cultivated oil seeds such as rape, mustard and sesame after the harvest of local broadcasting *aman* paddies. However, the gher farmers are not able to cultivate oil seeds due to the physical construction of gher farming. The gher farming system has increased vegetable production compared with the past. The farmers have also planted fruit trees (coconut, mango, guava, jackfruit, banana, papaya etc.) on the dikes. The production period of prawn and fish is from May / June to December / January; the MV *boro* paddy is from the end of January to the end of April, and vegetables are produced throughout the year.

As mentioned earlier, farmers in Chanchra usually practice the year-round paddy farming because the farms are located at relatively high altitude, where it is not possible to convert to the rice-prawn gher farming system like in the neighboring Bilpabla village. The MV *boro* paddies are produced from January to April, followed by a local variety of T. *aman* paddy from July to December. The cropping system of Chanchra is also presented in figure 2.

4. Inputs Used in MV Paddy Production under the two Farming Systems

Seeds, irrigation, chemical fertilizer and land preparation equipment were the main inputs of MV paddy production after the introduction of the green revolution. The main inputs used in MV paddy production under the rice-prawn gher and year-round MV paddy farming in southwest Bangladesh are discussed in this

Figure 2. Cropping patterns of the study villages



Source: Field survey, 2006.

Notes: ○ indicates the period up until the sowing of paddy, and releasing of prawn and fish is carried out.
● indicates when the harvesting period starts.
T. *aman* indicates transplanting *aman* paddy.

section.

4. 1 Chemical Fertilizer Input

Farmers use various types of chemical fertilizers to enhance the soil fertility for maximum rice yield. The farmers' practice of inorganic fertilizer management varied widely across and within the villages, as did the cropping patterns and seasons, soil textures, and geographical areas. Chemical fertilizers such as urea, triple super phosphate (TSP), muriate of potash (MP), gypsum, and zinc sulfate are commonly used in the year-round MV paddy production in Bangladesh. The gher farmers mainly apply urea, TSP, MP, and gypsum to MV *boro* paddy production. Usually the farmers do not use any chemical fertilizers except homestead manure and cow dung for local *aus* and T. *aman* paddy production. Application of chemical fertilizers for the MV paddy production of year-round paddy farming, and the MV paddy production under the rice-prawn gher farming system in Bilpabla are shown in table 2.

The table 2 shows, on average, more chemical fertilizer is used per *bigha* in the year-round paddy production in Chanchra compared with MV *boro* paddy production under the gher farming system in Bilpabla. It is interesting to

Table 2. Chemical fertilizers used in rice-prawn gher and year-round MV paddy farming

Types of fertilizers	Farming systems			Ratio	
	Gher farming	Year-round MV paddy farming			
	Boro Paddy (A)	*Boro* paddy (B)	*Aman* paddy (C)	B / A	C / A
Urea (Kg)	40.4	188.6	69.2	4.7	1.7
TSP (Kg)	31.4	94.5	34.8	3.0	1.1
MP (Kg)	4.3	48.0	11.6	11.2	2.7
Gypsum (Kg)	1.5	10.5	2.4	7.0	1.6
Amount of fertilizer used per *bigha* :					
Urea (Kg)	16.0	60.1	22.1	3.7	1.4
TSP (Kg)	12.5	30.1	11.1	2.4	0.9
MP (Kg)	1.7	15.3	3.7	9.0	2.2
Gypsum (Kg)	0.6	3.3	0.8	5.6	1.3

Source : Field survey, 2006.

Notes : (1) Sample sizes were gher and MV paddy farming for 90 and 100, respectively.
(2) TSP and MP indicate Triple super phosphate and Muriate of potash, respectively.
(3) The size of the sampled MV *boro* paddy farm under gher and MV paddy farming were 2.52 *bigha* and 3.14 *bigha,* respectively.

note that production per *bigha* varied significantly within the same farming system. Similarly, the amount of chemical fertilizer used in paddy production per *bigha* also varied significantly within the same farming system. It would appear that even though more chemical fertilizers are used in year-round paddy production compared with MV paddy production under the gher farming system, the yield is lower than that of year-round paddy farming in Chanchra (table 4).

4. 2 Irrigation Water Input

Water is the basic resource for agricultural production. It is a vital driving force for agricultural intensification and has significant impact on high yielding varieties (HYV) of paddy and wheat in South Asia, especially in India, Pakistan, Bangladesh, Nepal and Sri Lanka. Irrigation systems have increased rural household income significantly, and reduced poverty and inequality of income distribution through HYV paddy and wheat producing areas in Asia (Huang et al. [22]; Rosegrant and Evenson [29]; Datta et al. [17]; Saleth [31; Selvarajan and Subramanian [32]). Irrigation systems have also increased employment through HYV paddy and wheat producing areas in South Asia (Patel [27]).

4. 2. 1 Irrigation Water Input Used in MV Paddy Production under Gher Farming

Sources of irrigation and types of irrigation equipment and machines used are completely different with regards to MV *boro* paddy production under the rice-prawn gher farming system and year-round MV paddy farming, in the villages studied. As far as the physical construction of the rice-prawn gher farming system is concerned, the central paddy field is surrounded by canals, which retain sufficient water for irrigation of MV paddy production. The paddy fields of rice-prawn gher farming are irrigated from canals using indigenous handmade tools such as *doone* (indigenous homemade irrigation tool) and sewing baskets. The rich farmers who have large gher farms also irrigate the paddy fields using shallow tubewells. Recently, farmers have begun to make new canals inside the gher plots and fill the old canals using the soil from where the new canals were dug. The transformation and transplantation of the soil makes it fertile enough for optimal MV paddy as well as prawn production. Farmers believe that by

repositioning the canals every 3 or 4 years, the soil becomes more fertile for crop production.

4. 3. 2 Irrigation Water Input Used in Year-round MV Paddy Farming

Groundwater is used for the year-round MV paddy production in the study in Chanchra. As mentioned earlier, MV *boro* and MV *aman* paddies are being produced throughout year: MV *boro* paddy is produced from January to April, and MV *aman* paddy is produced from June to December. Irrigation is required for MV *boro* paddy production, and the farmers mainly irrigate the paddy field with groundwater using deep tubewells and shallow tubewells. In Bangladesh, deep tubewells are powered by electricity and shallow tubewells are powered by oil. As deep tubewells are very expensive and require electricity to pump groundwater, since the privatization of irrigation equipment in Bangladesh, the farmers purchase them collectively. On the other hand, because shallow tubewells are comparatively cheaper and require oil as fuel, the moderately well-off and rich farmers can easily purchase them privately to irrigate their paddy farms. In the study village, the farmers irrigate the paddy fields by both deep and shallow tubewells. At the paddy farms in areas not covered by deep tubewell water, the farmers cultivate MV *boro* paddies using shallow tubewell water.

MV *aman* is a rainfed crop that is produced in the rainy season in Bangladesh. Usually, no irrigation is required to cultivate MV *aman* paddy in the study village. Sometimes, a little irrigation is required to produce *aman* paddy, depending on the rain. At this time, the farmers irrigate the paddy fields using both deep and shallow tubewells.

In the case of deep tubewells, the irrigation cost for MV *boro* paddy production, which is fixed by the general members of the cooperative society, is Tk 500 per *bigha* per crop production. This amount does not depend on the amount of irrigation; farmers can irrigate the paddy fields with as much water as they need for smooth paddy production. Usually, the farmers irrigate the paddy fields 15－25 times, depending on the location of paddy fields, the amount of sunshine and the humidity. The irrigation cost for MV *aman* paddy production is fixed at Tk 100 per hour. Sometimes the farmers irrigate the *aman* paddy fields using groundwater. Usually the farmers irrigate the *aman* paddy fields once or twice, as required.

On the other hand, in the case of shallow tubewells, the amount of irrigation depends on the shallow tubewell's owner because the marginal and poor farmers have insufficient economic power to buy them. In the study village, the irrigation cost is fixed by the shallow tubewell owner at Tk 1,400 per *bigha* per crop production. Under the shallow tube scheme, compared with the owners, the marginal and poor farmers get less irrigation water to produce MV paddies.

4. 3 Plowing Input of MV Paddy Production under the two Farming Systems

Usually, paddy fields are plowed 2－3 times before transplanting, using power-tiller, bullock or tractor. In the year-round MV paddy-farming village, farmland is plowed using a tractor and power-tiller. After *boro* paddy harvesting, the paddy fields are plowed by tractor. Before the MV *aman* paddy transplantation, the paddy field is again plowed by power-tiller.

On the other hand, paddy fields of the rice-prawn gher farming system are plowed after paddy harvesting. The main reasons are that after prawn harvesting, the paddy fields（central field of gher farming）are not dry enough for plowing, or sometimes the paddy fields retain small amounts of water, which is also suitable for plantation. Moreover, soil in the central fields becomes clay-like for transplanting, because during prawn harvesting these soils are

Table 3. Main input costs of MV paddy production under the two farming systems

Cost Items	Farming systems			Ratio and level of statistical significance			
	Gher farming	Year-round MV paddy farming		Ratio	t-statistic	Ratio	t-statistic
	Boro Paddy (A)	*Boro* paddy (B)	*Aman* paddy (C)	B / A		C / A	
Fertilizers (Tk)	896	3,741	1,283	4.17	−6.60*	1.43	7.12*
Irrigation (Tk)	1,051	3,344	116	3.18	−2.86*	0.11	−1.24
Pesticides (Tk)	818	1,375	1,034	1.68	−8.62*	1.26	−2.55*
Land preparation cost (Tk)	677	1,392	1,321	2.06	−4.74*	1.95	−4.33*
Paddy production cost per *bigha* :							
Fertilizers (Tk)	356	1,191	409	3.35	−9.00*	1.15	19.34*
Irrigation (Tk)	417	1,065	37	2.55	−13.57*	0.09	2.61*
Pesticides (Tk)	325	438	329	1.35	−2.22*	1.12	1.99**
Land preparation cost (Tk)	244	295	276	1.21	−5.36*	1.13	3.32*

Source : Field survey, 2006.

Notes : (1) Sample sizes were gher and MV paddy farming for 90 and 100, respectively.
(2) The size of the sampled MV *boro* paddy farms under the gher and MV paddy farming systems were 2.52 and 3.14 bigha, respectively.
(3) *and ** indicate statistically significant values at 1% and 5% levels, respectively.

well mixed. However, a small number of paddy fields at comparatively high altitude and near to roadsides are also cultivated before transplanting, because the paddy fields are dry enough for plowing after prawn harvesting.

5. Input Costs of MV Paddy Production under the two Farming Systems

The main input costs of MV paddy production under the rice-prawn gher farming system and year-round MV paddy production are outlined in this section.

The average costs of chemical fertilizers, irrigation and pesticides, per farm as well as per *bigha*, for year-round MV paddy production in Chanchra and MV *boro* paddy production under the rice-prawn gher farming system, as well as their ratios, are presented in table 3. The table shows that, on average, the costs of chemical fertilizers, irrigation and pesticides, per farm as well as per *bigha*, were higher in the year-round MV paddy production in Chanchra, compared with MV *boro* paddy production under the rice-prawn gher farming system in Bilpabla. The cost of chemical fertilizers per *bigha* for MV *boro* paddy production under the year-round MV paddy farming system was more than three times higher than that of MV *boro* paddy production under the rice-prawn gher farming system. Similarly, with the exception of MV *aman* paddy production, the irrigation cost per *bigha* was higher for MV *boro* paddy produced by the year-round MV paddy farming than it was for the rice-prawn farming system. The cost of pesticides per *bigha* was almost the same for the MV *boro* paddy production under both types of farming systems. Table 5 also shows that within the year-round MV paddy production, the costs of chemical fertilizers, irrigation and pesticides per *bigha* were higher for MV *boro* paddy production compared with its counterpart MV *aman* paddy production. The main reason is that the MV *aman* is a rain-fed crop in Bangladesh, and all the paddy fields are submerged under water during the growth period of the crop.

6. Input and Output Prices of the two Farming Systems

To show the complete overview of the rice-prawn gher and year-round MV paddy farming systems, the main input and output prices are discussed in this section.

6. 1 Input and Output Prices

As mentioned in the introduction, prawn and MV *boro* paddy are the main products of the rice-prawn gher farming system. In the early stages of rice-prawn gher farming（1985－1995）, farmers mainly used the meat of mud snails collected from small rivers, canals, swamplands and local ponds, as prawn feed. When the whole of the wetlands（swamplands）were converted into gher farming, mud snails gradually disappeared from these areas. Now farmers are applying various combinations of feed to prawns, on the basis of a trial-and-error method. The main input and output price of the rice-prawn gher farming system and year-round paddy farming system are presented in table 4.

The price of inputs（prawn fingerlings）and outputs（prawn）depends on the releasing and harvesting times. The time of releasing prawn fingerlings into gher is from May to the end of July. Usually, the cost of prawn fingerlings is higher in the early stage（May-June）of releasing time. At that time, fingerlings cost Tk 3,000 per thousand; after June this price dropped to Tk 2,000. The price of the main meat-of-mud-snail feed depends of the supply and demand in the locality. The price of mud snail has increased more than five times from the introduction of gher to 2003（Barmon et al. [6]）. The price of other inputs（fish meal, oilcake, broken rice, pulses, wheat, etc）of prawn production does not vary much in one production cycle（year）. On the other hand, the price of output prawns depends on their size（in volume and quantity）and harvesting time.

The main inputs of MV paddy production in the two study villages vary because of location. The local market price of urea was 9.5 Tk/Kg in the gher farming area, whereas it was 7 Tk/Kg in the year-round MV paddy-farming village, mainly because of additional transportation

Table 4. Main input and output prices of the rice-prawn gher and year-round MV paddy farming

Rice-prawn gher farming			
Main inputs of prawn production	Mean	MV *boro* paddy production	Mean
Fingerling cost（Tk/1,000）	2,450	Urea（Tk/Kg）	9.5
Fish fingerling（Tk/Kg）	65	TSP（Tk/Kg）	14
Fishmeal（Tk/Kg）	22	MP（Tk/Kg）	15
Meat of mud snail（Tk/Kg）	10	Gypsum（Tk/Kg）	3
Oilcake（Tk/Kg）	18	Paddy grain（Tk/Mound）	420
Broken rice（Tk/Kg）	13	Paddy grain yield（mound/bigha）	27
Wheat（Tk/Kg）	13		
Chira（Tk/Kg）	16		
Pulses（Tk/Kg）	17		
Prawn（Tk/Kg）	435		
Year-round MV *boro* and *aman* paddy farming			
MV *boro* paddy prodcuction	Mean	MV *aman* paddy production	Mean
Urea（Tk/Kg）	7	Urea（Tk/Kg）	7
TSP（Tk/Kg）	18	TSP（Tk/Kg）	18
MP（Tk/Kg）	16	MP（Tk/Kg）	16
Gypsum（Tk/Kg）	3	Gypsum（Tk/Kg）	3
Paddy grain（Tk/Mound）	484	Paddy grain（Tk/Mound）	440
Paddy grain yield（Mound/bigha）	24	Paddy grain yield（mound/bigha）	21

Source : Field survey, 2006.

Notes : (1) TSP and MP indicate Triple super phosphate and Muriate of potash, respectively.

(2) 1US $ = 72.65 Taka（Tk）, December, 2006.

(3) One *mound* is equal to 40 Kg in the locality.

Table 5. Main input and output prices of prawn production over the year

Input/Output items	Year				
	1990	2001	2003	2005	2006
Prawn fingerling/ 1,000	250				2,450
Meat of mud snail/Kg	2.5	5	7	8	10
Fishmeal (Tk/Kg)	−	14	16	20	22
Oilcake (Tk/Kg)	−	10	12	15	18
Broken rice (Tk/Kg)	−	8	8	10	13
Wheat (Tk/Kg)	−	7	8	12	13
Chira (Tk/Kg)	−	10	12	16	16
Pulses (Tk/Kg)	−	14	15	16	17
Prawn (Tk/Kg)	200	300	350	400	435

Souces : Field survey, 2002, 2004, 2006.

costs. Similarly, the market price of TSP and MP also varied because of distance. The output (paddy grain) price has varied from 420 to 484 Tk/mound between the gher and year-round paddy-farming villages. Paddy price per unit is higher in the year-round MV paddy-farming village compared with the gher-farming village, mainly because of the harvesting and drying process, as well as the distance to the local market. The market price of the main inputs and output of prawn production over the year is presented in table 5. The figures in the table show that the price of main input prawn fingerling per unit, and the price of meat of mud snail have increased by about 10 and 4 times, respectively, between 1990 and 2006, whereas the output price has only increased by about 2.5 times during the same time.

6. Labor Input

The utilization of labor in agricultural sectors depends on many factors, such as cropping patterns, cropping intensity, potentiality of irrigation, and other intensive agricultural activities (Suryawanshi and Kapase [34]). The green revolution has changed the agricultural land and labor productivity, and it has had considerable impact on labor demand and/or employment in developing countries. The adoption of new technology has substantially increased total agricultural employment, and has significantly contributed to the household income by increasing labor demand in developing countries (Estudillo and Otsuka [18]). The diffusion of modern technology has increased the size of the labor market by increasing the demand for hired labor in Bangladesh (Hossain et al. [21]). However, Alauddin and Tisdell ([3]) argued that modern agricultural technology increased labor demand four-fold from the 1960s to the 1980s in the dry season, but the labor demand was stagnant in the wet season. The employment-generating effects of modern agricultural technology have slowed down in recent years in Bangladesh. The green revolution has increased labor absorption at its early stage, but the labor absorption decreased in most developing countries after the adoption of the new labor-saving chemical and mechanical innovations (Jayasuriya and Chand [23]).

6. 1. Labor Input Used in Gher and Year-round Paddy Farming

The rice-prawn gher farming system has created more temporarily-hired and permanently-hired labor as well as family labor demand compared with the year-round MV paddy farming, in southwest Bangladesh. Gher farming is a labor-intensive farming system. Temporarily and permanently-hired labor

mainly depends on family labor（Barmon et al.［12］; Rutherford［30］; and Kendrick［24］).

Usually, family laborers and temporarily-hired laborers are used for MV *boro* and *aman* paddy production. Temporarily-hired laborers are employed on a daily basis at the prevailing market wage rate at the time of employment.

6. 2 Comparisons in Labor Input

The rice-prawn gher and year-round MV paddy farming are completely different in terms of management and production processes. Therefore, labor utilization per unit is also different in the two agricultural systems. Barmon et al.（［12］）conducted research on labor demand in the gher, year-round MV *boro* and local *aman* paddy farming in the same area. However, this study attempts to compare the labor used in the rice-prawn gher, year-round MV *boro* paddy and *aman* paddy farming villages.

The utilization of labor input for the rice-prawn gher and year-round MV paddy farming is presented in table 6, and shows that about four times more male laborers were hired in various gher farming operations compared with its counterpart MV *boro* paddy production, under gher farming. Similarly, 3 times more female laborers were hired in MV paddy production, under the gher farming system. Along with hired laborers, more family（male and female）laborers were used in various gher-farming activities. Family laborers mainly engaged in supplying feed to prawns, and monitoring to prevent poaching prawn from the gher. On the other hand, both male and female hired laborers were used more in *boro* rice production than in MV *aman* paddy production. However, female family laborers were used to the same ex-

Table 6． Labor input use and wage rate for rice-prawn gher and year-round MV paddy farming

Farming systems	Labor input				Wage rate（Taka / day）	
	Hired		Family			
	Male	Female	Male	Female	Male	Female
Gher farming						
Prawn production（man-day）	177	17	215	26	100	90
MV *boro* paddy（man-day）	39	6	10	6	120	90
Total	216	23	225	32		
Year-round paddy farming						
MV *boro* paddy（man-day）	66	10	12	2	80	60
MV *aman* paddy（man-day）	52	9	12	2	90	70
Total	118	19	24	4		
Per bigha labor demand						
Gher farming						
Prawn production（man-day）	44	4	53	6	Na	Na
MV *boro* paddy（man-day）	16	2	4	2	Na	Na
Total	60	6	57	8		
Year-round paddy farming						
MV *boro* paddy（man-day）	21	3	4	1	Na	Na
MV *aman* paddy（man-day）	17	3	4	1	Na	Na
Total	38	6	8	2		

Source：Field survey, 2006.

Notes：(1) One man-day is equal to 8 hours per day.

(2) Average gher farms and MV *boro* paddy fields were 4.09 and 2.52 *bigha,* respectively.

(3) Average year-round paddy farm was 3.14 bigha.

(4) One *bigha* is equal to 0.5 acres or 0.2024 ha in the locality.

(5) "Na" indicates not applicable.

tent for both MV *boro* and *aman* production.

Table 6 also reveals that hired male labor was about two times higher in MV *boro* paddy production per *bigha* in the gher farming system compared with MV *boro* and *aman* paddy production. Gher farmers used more family laborers compared with the year-round MV *boro* and *aman* paddy production. The gher farmers used female laborers about two times more than farmers involved in rice production.

The wage rate is primarily determined by the demand and supply of labor. The wage rate of temporarily-hired labor depends upon the different gher farming activities, and varies each month. The agricultural wage rate also varies between male and female labor. The agricultural wage rate of male and female labor for the gher farming activities and year-round MV *boro* and *aman* farming are presented in table 6.

It is evident from table 6 that the wage rate of male labor was Tk 100 per working day, for various gher farming activities, whereas it was Tk 120 for MV *boro* paddy production under the gher farming system. One of the main reasons is that the people of the study area are not interested in working in paddy production activities such as seedling planting, weeding and harvesting. At the same time, the local farmers usually engage themselves in gher farming activities such as dike repairing, and maintenance activities. Gher farmers usually obtain this temporarily-hired labor from the local labor market on a weekly basis. These hired laborers come from the nearby villages, where employment is not available or is sometimes at a cheaper wage rate. These types of temporarily-hired laborers stay at the gher farm with the owners, or sometimes temporarily rent a room for cooking meals and sleeping. The wage rate of male and female laborers for MV *boro* and *aman* rice cultivation is lower than that of *boro* rice production of the gher farming system.

Therefore it could be concluded that the change in agricultural technology has significant impact on labor demand. In other words, compared with the year-round MV paddy farming, the gher farming system has created a higher labor demand for both hired and family labor.

7. Agricultural and Household Income of the two Farming Systems

The cost of items associated with the gher farming system includes the cost of prawn and carp fish fingerlings, various kinds of feed, labor, medicine, watching house, paddy and vegetable seed/seedlings, land preparation (bullock), irrigation, pesticides and fertilizers. Gross return of gher farming includes revenue from prawn, fish, paddy and vegetables. The costs, gross revenue, and profit of gher and the year-round paddy farming are presented in table 7 (detail explanation in Barmon et al. [10]).

7.1 Household Income of Gher and MV Paddy Farmers

Components of household income, their ratio and t-statistic are presented in table 8. The table shows that agricultural income remains the principal source of income for households in the sampled gher and year-round paddy-farming villages in the study. Farm income of gher farmers was more than five times higher than that of farmers involved in the year-round paddy farming. The family labor income of gher farmers was about four times higher than that of year-round MV *boro* and *aman* paddy farmers. The main reason is that the rice-prawn gher farming system has created self-employment opportunities for the gher farmers in comparison with the year-round MV paddy production. However, the family off-farm income of gher farmers was about two times lower than that of paddy farmers. The main reason is that paddy farming was not a profitable enterprise like rice-prawn gher farming; therefore,

Table 7. Cost and returns of rice-prawn and year-round MV paddy farming system

Particulars	Gher farming	MV paddy farming
Prawn production	Bilpabla village	Chanchra village
A. Variable costs	(Taka)	(Taka)
1. Prawn fingerlings	45,080	−
2. Carp fingerlings	1,155	−
3. Feed	57,419	−
4. Hired labor	19,734	−
5. Family labor	23,785	
6. Medicine	1,470	−
Sub total (A)	148,643	−
MV paddy production		
B. Variable costs		
1. Seedlings	972	1,583
2. Land preparation	677	2,713
3. Hired labor	4,500	11,185
4. Family labor	1,677	2,297
5. Irrigation	1,051	3,460
6. Pesticidies	818	2,409
7. Fertilizers	896	5,024
8. Others	652	522
Sub total (B)	11,243	29,193
C. Fixed costs		
1. Dep. of gher preparation	1,007	−
2. Monitoring house	678	−
3. Farm land	12,567	18,800
4. Land rent	9,722	1,478
Total fixed cost (C)	23,974	20,278
D. Total cost (A+B+C)	183,860	49,471
E. Revenue		
1. Prawn	262,408	−
2. Fish	13,045	−
3. Paddy	28,713	64,812
4. Straw from paddy	2,719	9,051
5. Vegetables	403	−
Total Revenue (E)	307,288	73,863
Total Profit (E−D)	123,428	24,392

Source : Field survey, 2006.

Notes : (1) Number of gher and MV paddy farms sampled was 90 and 100, respectively.
(2) Average gher and MV farm sizes were 4.09 *bigha* and 3.14 *bigha,* respectively.
(3) One *bigha* is equal to 0.5 acres or 0.2024 ha in the locality.
(4) 1US $ =72.65 Taka, December, 2006.
(5) Depreciation of gher construction and the monitoring house was calculated by the straight-line method. In this method the depreciation is calculated by dividing the total expected depreciation value equally among the expected number years of the life of the gher (Hopkins and Heady [20]). On the basis of the farm survey data, the economic life of gher farming was considered to be 25 years.

the paddy farmers were engaged in varies types of off-farm activities. The agricultural wage income of gher farmers was significantly (two times) lower than that of MV paddy farmers. The main reason is that farm owners exchange their family labor with others during the prawn

Table 8. Household income of gher and MV paddy farmers

Source of incomes	Gher farming	MV paddy farming	Ratio	t-statistic
	Bilpabla village	Chanchra village		
	(Taka)	(Taka)		
Farm income (Profit from farming)	123,428	23,874	5.17	5.85*
Agricultural wage income	9,672	15,820	0.61	−3.87*
Family labor income	25,462	6,385	3.98	22.11*
Farm land income	12,567	18,800	0.67	−2.61*
Off-farm income	8,889	18,720	0.47	−2.63*
Livestock income	12,184	7,599	1.60	2.68*
Homestead gardening income	276	279	0.99	−
Total Household income	192,478	91,477	2.10	5.20*

Source : Field survey, 2006.

Notes : (1) Number of gher and MV paddy farms sampled was 90 and 100, respectively.
(2) Average gher and MV farm sizes were 4.09 *bigha* and 3.14 *bigha,* respectively.
(3) One *bigha* is equal to 0.5 acres or 0.2024 ha in the locality.
(4) 1US $ = 72.65 Taka, December, 2006.
(5) *indicates statistically significant value at 1% level.

-harvesting season. Moreover, the family members take care of the farming by themselves during the whole prawn production cycle. The income from livestock was also higher for gher farmers compared with MV paddy farmers, indicating that the gher farming system has also positive impact on livestock. Therefore, it is concluded from the table that rice-prawn gher farmers have gained more agricultural income as well as household income compared with paddy farmers.

The t-statistic was used to show the significant levels of different components of household income between the rice-prawn gher and year-round MV farming. The value of the t-statistic indicates that all components of household income between the two farming systems were significantly (statistically significant at the 1% level) different to each other.

7. 2 Per Capita Household Income

The per capita household income of the gher farmers, year-round MV paddy farmers and the people of rural Bangladesh are presented in table 9. In this study, a family is defined as a group of people living together and taking meals jointly in one kitchen, and under one family head. Permanent hired laborers are not included as members of the family. This study considers same weight for children and

Table 9. Comparison of per capita houshold income among gher farmers, MV paddy farmers and the other people of Bangladesh

Particulars	Avergae family size (Number)	Household income per farmily (Tk/Year)	Per capita household income (Tk/Year)	t-statistic
Gher farmers	4.36	192,478	44,146	5.20*
MV paddy farmers	4.30	91,477	21,273	
Bangladesh				
Rural people	5.19	57,790	11,135	−
Urban people	5.13	118,537	23,106	−
All	5.18	70,102	13,533	−

Source : Authors' calculation and BBS, 2002.

Note : *indicates statistically significant value at 1% level.

adult men and women in regards to family size. The average family size of the households in Bilpabla and Chanchra village were 4.36 and 4.30, respectively, which were lower than national average (5.18; BBS [14]). The table shows that the per capita household income of gher farmers was about four times higher than that of the rural people, as well as that of the whole of Bangladesh. The per capita household income was also more than double that of the year-round MV paddy farmers (statistically significant at the 1% level) as well as of that of the urban people of Bangladesh. Therefore, it could be concluded that the rice-prawn gher farming system has increased not only household income but also per capita household income, compared with other farming systems and the people of both rural and urban Bangladesh.

8. Concluding Remarks

Rice-prawn is an indigenous technology solely developed by farmers since the mid-1980s. Under the rice-prawn gher farming system, MV paddy and prawn are being produced one after the other throughout the year. On the other hand, MV *boro* and *aman* paddy are being produced under the year-round paddy farming in the study village. The findings indicate that there are comparatively fewer inputs (mainly chemical fertilizers, irrigation and land plowing) used in MV *boro* paddy production under the rice-prawn farming system than with the year-round paddy farming system.

Chemical fertilizer, irrigation and pesticides are the main inputs of paddy growth. Per-unit chemical fertilizers, irrigation, and pesticides used in MV paddy production under the two farming systems are statistically significantly different to each other. The findings indicate that more chemical fertilizers, such as urea (73%), TSP (59%), MP (88%) and gypsum (82%) are used per *bigha* in the MV *boro* paddy production under the year-round paddy farming, compared with gher farming. As the irrigation water use in MV *boro* paddy is different, the irrigation cost per *bigha* was higher (61%) than in MV paddy production under gher farming. The pesticides (26%) and land preparation (17%) costs per *bigha* were also lower for MV *boro* paddy production under the gher farming system.

Rice-prawn gher farming is labor-intensive and creates self-employment throughout the year, compared with the year-round MV paddy farming. The gher farming system also plays a pivotal role in absorbing the surplus labor force in rural areas. This self-employment has significant impact on household income.

The MV *boro* grain yield per *bigha* was higher in the gher farming system, compared with the year-round MV *boro* and *aman* paddy production. Farmers have gained more agricultural income (more than five times higher) as well as household income (more than double) from gher farming, compared with MV *boro* and *aman* paddy production in Bangladesh. The household income per capita in the gher farming area was about double that of the MV paddy farming area, and about four times higher than that of the people in rural Bangladesh. Therefore, it can be concluded that the gher farming system has created a good production environment for MV paddy farming. This farming system has also created employment opportunities both for hired and family labor, which has significant impact on household income.

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