IMPACT OF RICE-PRAWN GHER FARMING ON AGRICULTURAL AND HOUSEHOLD INCOME IN BANGLADESH: A CASE STUDY OF KHULNA DISTRICT

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ABSTRACT

The present study evaluates the impact of rice prawn gher farming on agricultural income as well as household income in Bangladesh. The research was conducted in Bilpabla village under Dumuria Thana in Khulna District using primary and secondary data. The impact of gher farming on agricultural income was examined by the production cost and total revenue of prawn, fish, paddy and vegetables. The production cost and revenue of local *aman* were used as the benchmark for the changes in income of the farmers. Secondary sources of information were used for the benchmark data. The gher farming system has changed the cropping patterns dramatically with diverse products like prawn, carp fish, *boro* paddy, and vegetable in the field where only single crop of paddy was cultivated before the introduction of gher farming. *Gher* farming system is a profitable enterprise compared to paddy production. As a result, gher farming system has increased agricultural income for owning and renting farmers. The agricultural income of renting farmers from gher farming was about 23 times higher than sharecropper's agricultural income from local *aman*, whereas, the agricultural income for owning gher farmers was about nine times higher than owning paddy farmer. Therefore, change in agricultural income from gher farming has greater impact on renting farmers than owning farmers. The study found a positive impact of gher farming on agricultural income as well as household income in the study area.

Introduction

Bangladesh is climatically suitable for aquaculture. With a large number of rivers, *beels, baors, haors* and ponds, it has a long tradition of aquaculture. Bangladesh is also rich in marine and inland biodiversity. In Bangladesh, there are about 4 million hectares of open inland water body and about 4.3 million hectares of closed water body and about 710 km of coastal lines. Bangladesh also possesses 210 nautical miles of Exclusive Economic Zone (EEZ) in the Bay of Bengal, which plays an important role in aquaculture (BBS, 2001). Fishery is one of the major sub-sectors of the country's agricultural sector and is important for both economic and nutritional reasons. Fish supplies about 63 percent of animal protein and about 1.2 million people are directly employed in fisheries, while an additional 11 million people are indirectly employed in upstream and downstream activities related to shrimp/prawn culture such as harvesting, culture, processing and exporting (DOF, 2000). The fishery sector contributes about 5.23 percent of the GDP in 2002 (GPN, 2003). Among fishery sub-sectors, prawn (*Macrobrachium rosenbergii*) and shrimp (*Penaeus monodon*) are very important exportable items for Bangladesh, which account for about 9 percent of total national exports (Talukder, 1999). This sector grew at the rate of around 9 percent per annum during the last decade (Bhattacharya et al., 1999). Shrimp/prawn has replaced raw jute (the golden fibre of Bangladesh) as the dominant export item and contributes nearly half of the export items in the primary goods category. Therefore, shrimp and prawn are now called the "white gold" of Bangladesh.

The landholding size, cropping patterns as well as land tenant system have changed after the introduction of gher farming in southwest Bangladesh in late 1980s. As a result, socioeconomic conditions, labor movement and income level of the gher farmers has changed. However, there are few studies that focus on labor demand for male and female workers, daily wage rate, cost and benefit analysis of fresh water rice prawn gher farming and the impact of shrimp gher farming on the environment and ecology in the coastal region in Bangladesh. The rice prawn gher farming has positive impacts on both male and female labor markets compared to MV *boro* and local *aman* paddy. The poorest and landless households benefit from gher farming due to greater employment opportunities and higher wages (Barmon, et al, 2003). Shrimp gher farming has negative impacts on environments in the coastal region in Bangladesh (Asaduzamman et al, 1998; Nijera Kori 1996; Nabi et al 1999; Rahman et al, 1995; and Sobhan 1995), whereas the impacts of rice prawn gher on the environment are ambiguous. But the rice prawn gher farming has negative impacts on the ecology and a large number of indigenous species of fish have already disappeared (Datta 2001). The value of farmland has increased about tenfold compared to the time before rice prawn gher (Kendrick, 1994). Indeed, the impact of rice-prawn gher farming on household income has received very little attention. Therefore, the present study evaluates the impact of rice-prawn *gher* farming on agricultural income as

well as household income in southwest Bangladesh. It is hoped that the study will help farmers, extension workers, researchers, policy makers, and concerned authorities in the development of rice-prawn gher farming in Bangladesh.

This paper is organized as follows. Following the introduction, section two discusses the methodology of the study. Profile of the study village, gher management and history of gher farming are briefly explained in section three, whereas impacts of gher farming are presented in section four. The results and discussions are presented in section five and conclusions are offered in section six.

Methodology of the Study

The study was conducted in Bilpabla village in Khulna district of southwest Bangladesh. Bilpabla village and Khulna District were purposively selected because almost all of Khulna district is being cultivated for rice-prawn gher farming and the people of Bilpabla village have good experiences with rice-prawn gher farming. Primary and secondary data were used in the present study: primary data were collected through a comprehensive cross-sectional field survey, whereas the secondary data were collected from the Bangladesh Bureau of Statistics (BBS) and World Rice Statistics. The survey was conducted from November to December 2003. In Bilpabla village, the survey consisted of two stages. First, all households in the village were identified. Second, out of all gher farm households 31 gher farmers and 31 tenant gher farmers were randomly selected.

After tabulation, necessary adjustments such as conversion from local unit (like *bhiga*) to standard unit (like *hectare*) were made. The converted data were then summarized, and tabulated in accordance with the objective of the study. Since the rural households' activities are not generally recorded, it is difficult to estimate household income accurately, particularly for unpaid households' activities. Most rural households are also involved in many expenditure-saving activities for family consumption such as homestead fruits, vegetables gardening, poultry and livestock rearing, fishing nearby swamplands and canals, processing food, and manufacturing personal and household effects. The rice-prawn gher farmers and MV paddy farmers also do not normally maintain such types of records properly. Therefore, there may be a tendency to under or over report these activities in the present study.

The present study has some limitations. Even though the researchers collected primary data from the study village directly, some farmers were afraid to give proper information to an unknown person. The farmers may have thought that the researchers are government officers and came to collect income tax. The researchers did not collect information from these types of farmers. Rice prawn gher farming is practiced only in southwest Bangladesh especially in greater Khulna district. As Bilpabla is one of the typical rice prawn gher farming village in greater Khulna district, it represents only the southwestern part of Bangladesh where the farmers are practicing rice prawn gher farming.

Profile of the Study Village and *Gher* Managemant

Description of the Study Village

Bilpabla is one of the typical villages in Dumuria Thana in Khulna District and is located about 7 kilometers west of the district headquarter of Khulna, and about 310 kilometers south from the capital Dhaka. Bilpabla village is divided by a small river and the households of this village are mainly living on both sides of the river (Figure 1). The land of this village area is defined as medium high land, and the soil quality is alluvial, loamy and sandy. The demographic characteristics of the village are similar to any other prawn farming village.

Gher farming is the main occupation in this village. Along with gher farming the people are also engaged in other activities such as prawn business, integrated culture, van pulling, boating, mud snail crushing for prawn feed, and other formal and informal activities both inside and outside of village. Before the gher farming had started, the villagers were mainly farmers, day labors, and fishermen.

There are no recreational facilities or organized playgrounds in the study area. Television and radio are the main means of recreation. Only 54 (14%) households have Black and White televisions (B&W), and 238 households (about 59%) have radio and tape recorders for recreation (Field Survey, 2003). But this number is increasing every year. Before gher farming, there was no television in this village.

The people use kerosene oil lamps or hurricane lanterns at nighttime and usually finish dinner by 9.00 pm and go to bed early. School-going children usually study during the day. Sometimes the bright students do their homework at night. The villagers do

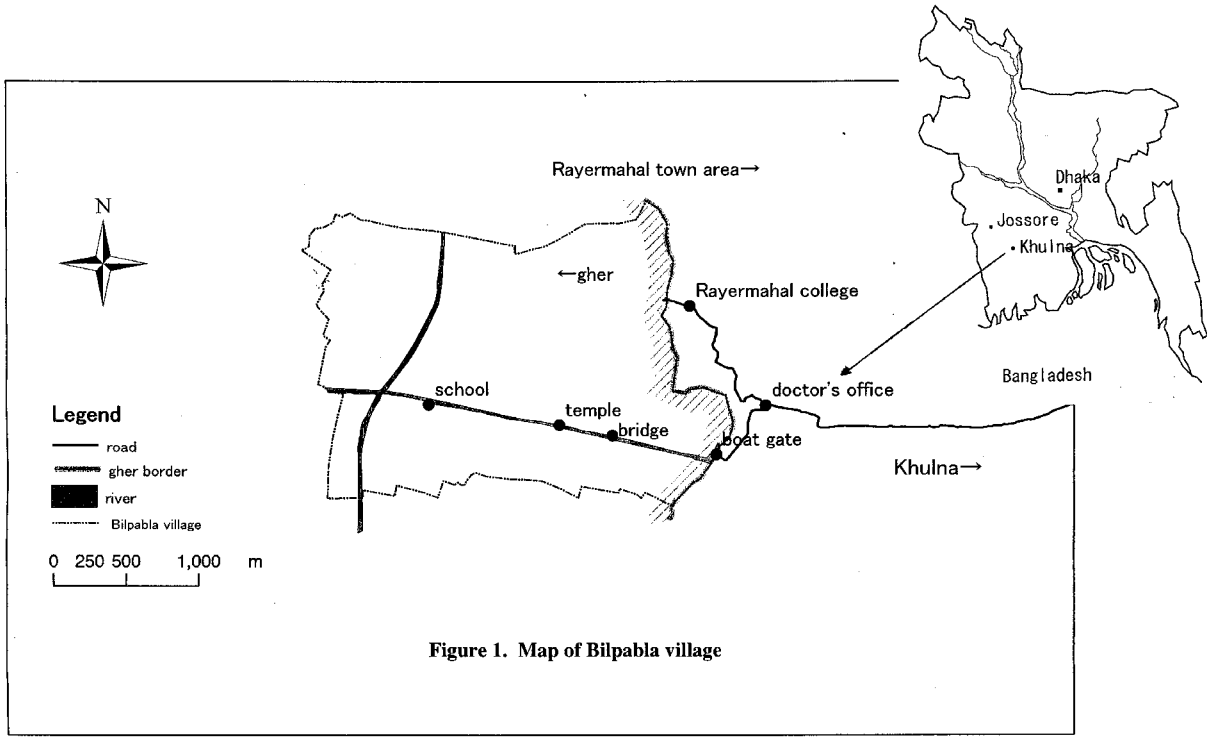


Figure 1. Map of Bilpabla village

not have good toilet or safe drinking water facilities. Only 77 families (20%) have brick toilet facilities. The others have semi brick toilets or no hygienic toilets. There are only 12 tube-wells in this village but the villagers mainly use this water for cooking purposes because the water contains a lot of iron. The people bring safe drinking water from nearby villages (Field Survey, 2003).

In this study, a family is defined as a group of persons living together and taking meals jointly in one kitchen and under one family head. Permanent hired labors are not included as members of the family. Bilpabla village has a total of 401 households with a total population of 1893 people with 53 percent male and 47 percent female. Most of the people (about 98%) of this village are *Hindu*. The people of this village send their children only to primary and high schools because of limited access to higher education facilities. There is only one government primary school in this village. Some educated farmers usually send only their sons to the high school of nearby villages. The households are not interested in sending their daughters to high school due to social problems and also as these high schools are far from this village. The literacy rate of the village is increasing up to the high school level, but after completing high school (i.e. 5 to 10 year schooling) parents stop sending children for higher studies.

Gher Crops and Management

Traditionally, rice-fish integrated farming is practiced in many countries in South and Southeast Asia especially in China, India, Bangladesh, Thailand, Cambodia, Korea, Malaysia, and Vietnam. The cultivation of most rice crops in irrigated, rainfed and deepwater systems offer a suitable environment for fish and other aquatic organisms. Fish are cultured in paddy fields simultaneously in traditional rice-fish systems to obtain additional protein for household consumption. Nowadays the traditional rice-fish culture is practiced on a commercially basis.

Rice-prawn culture is different from the traditional rice-fish monoculture because of the difference in farm management system and structure of production unit. Gher is a modified rice field having high wide dikes and a canal inside the periphery of the dikes that retains water during the dry season. It is the physical construction used for freshwater prawn (*Macrobrachium rosenbergii*) farming. At the early stages of gher farming most of the farmers cultivated prawn in monoculture ponds, but it is now common for the farmers to grow fish with prawn. In addition to this, paddy, vegetables and fruit trees are also grown alongside gher farming. The gher cycle begins in May/June when the farmers release prawn post larvae (PL) into the gher. Before this, farmers repair the gher dikes and trenches almost every year. Farmers use lime (30-40 Kgs per hectare) during gher preparation to reduce soil acidity. During the grow-

out period, the farmers give supplementary feed to the prawn. Different farmers give different combinations of feed to prawn production and they do not maintain standard feed combination that would help produce an optimum prawn yield. Traditionally, only snail meat was used as prawn feed, but nowadays in addition to snail, farmers use a wide range of homemade and commercial supplementary feeds. Carp fish fingerlings are released into gher in June/July and cultured for eight months as long as sufficient water is retained in the gher. Usually, no specific supplementary feeds are provided for fish. Fish share the feed supplied for prawn cultivation.

During the winter season (January to April) farmers usually grow *boro* paddy on gher *chatal* (the land inside the gher). Farmers usually irrigate the paddy fields from canals using indigenous hand made tools such as *done* (one kind of indigenous hand-made irrigation tool), and basket. Some-times farmers do not irrigate the paddy field. In general, the gher farmers do not use any types of organic fertilizer for *boro* paddy production as the remains of the feed nutrients that the farmers put in the gher during the prawn and carp fish production supplement paddy field fertility. The farmers usually grow vegetables both during winter and summer seasons on the dikes.

History of Gher Farming in Study Village

Rice-prawn gher farming is a new indigenous agricultural system solely innovated by farmers in the southwest Bangladesh during mid 1980s. The southwest region (Khulna, Bagerhat, Satkhira, and Jessore districts) experienced a period of severe environmental change between 1960s and 1980s. Many people in this region blame 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. The embankments were designed to limit saline intrusion so that more land could be brought under cultivation but the resulting environmental changes actually served to drastically constrain agricultural production. There were many seasonal and perennial *beels* (low-lying land is locally known as *beel*) before embankment construction and farmers used to grow one or two rice crops every year (deepwater *aman* rice during the monsoon and some *aus* during the winter season) in these seasonal *beels* and low-lying agricultural lands. However, some seasonal *beels* and low-lying areas became permanently water logged after the construction of embankments and polders. The natural flood plain dynamics were disrupted and saline intrusion actually increased in some areas. A large number of farmlands were rendered agriculturally due to saline intrusion and water logging in Fakirhat and Chitalmari Thanas under Bagerhat district. Consequently, people of these areas suffered increasing poverty and food shortages. During the crisis, people used to eat wild foods like water lily and its seeds for survival. Most of the people were unemployment in the rural areas and people started migrating to big cities looking for work. At the same time, a few farmers in Fakirhat Thana began to experiment with Giant freshwater prawn (*Macrobrachium rosenbergii*) cultivation. They obtained good results in terms of growth and the neighboring farmers gradually adopted the practice. At that time farmers did not use any supplementary feed and wild Post Larvae (PLs) were cheaply available and the production was very profitable. But till the 1980's there were no prawn exports from Bangladesh. Farmers sold their harvest in the local markets. 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 news about this technology quickly spread to neighboring Thanas and Districts, and the so-called gher revolution had begun (Kendrick, 1994).

Nripendranath Biswas first introduced rice prawn gher farming in Bilpabla village in 1989. Mr. Biswas got married in Kurshail village in Fakirhat Thana of Bagerhat district on 1986. His brother-in-laws practiced rice prawn gher farming since 1984 due to its high profit. In 1988, Mr. Biswas discussed with his brother-in-laws about gher farming as well as gher management system to introduce it in his area. After fruitful discussions with his brother-in-laws he came back to his own village and discussed with his father about gher farming. Soon after he introduced gher farming according to his brother-in-laws' advice in 1989. He did not produce paddy after harvesting of prawn until 1991 due to lack of information. He believed that if he cultivated paddy after the harvesting of prawn the land fertility would decrease due to paddy production and as a result, the production of prawn would decrease. He went to Khurshail village again in 1992 to visit his brother-in-laws' house and heard that the gher farmers were producing paddy after harvesting prawns. He started to cultivate paddy production from 1993 and saw that the prawn production was not affected by paddy

production. From 1993 he is producing paddy after harvesting prawns. The other farmers also began to practice gher farming seeing the success of Mr. Biswas and gradually the paddy fields were converted into gher farming in 1997 (Field survey, 2003).

Impact of Gher Farming

Impacts of Cropping Patterns

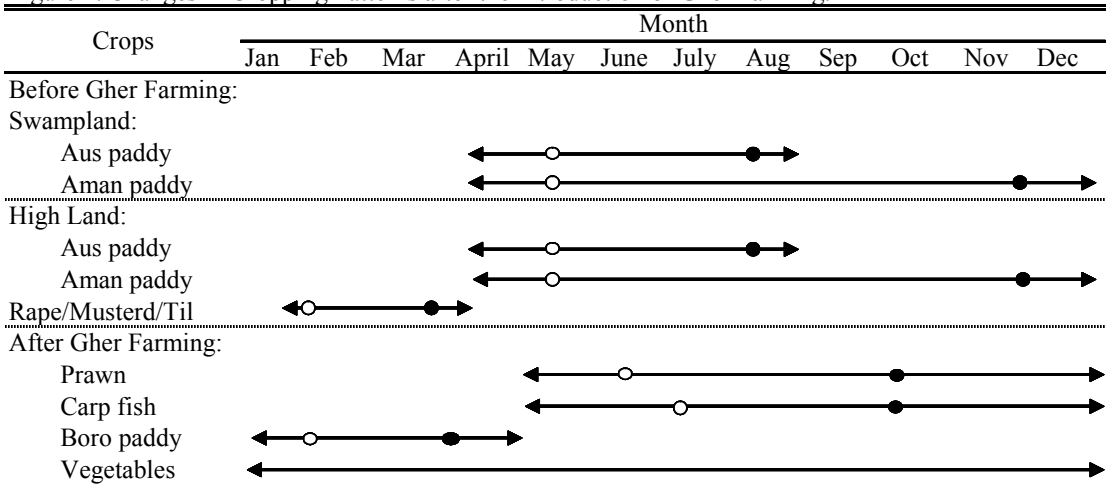
Prior to *gher* farming, the farmers cultivated local *aus* and local *aman* paddy in the swampland. Oil crops, such as rape, mustard and *til* (one kind of oil seed crop), are also produced along with local *aus* and *aman*. The life cycle of local *aman* is longer than local *aus* though the sowing time is the same for both types of paddy. Sowing of *aus* and *aman* paddy is in April/May and harvesting time is in August for local *aus* and November for local *aman*. The farmers sowed *aus* and *aman* together in April/May because after June/July the whole area is water logged due to heavy rain and at times it is not possible to plant transplanted *aman* (*T. Aman*). This was the most popular cropping system before the introduction of the rice prawn *gher* farming system, which was locally known as *Domuti*.

Gher farming system has changed the cropping patterns dramatically in the study area. Rice-prawn gher farming has created an ideal opportunity for crop diversification. Along with prawn and carp, the farmers can now cultivate *boro* paddy in the fields and vegetables on the dikes of the gher mainly for home consumption. Before the ghers had started, the farmers cultivated rape, mustard and/or *til* after the harvest of local *aman* paddy (January to April) but the gher farmers are presently not able to cultivate oil crops due to physical construction of gher farming. However, gher farming has increased vegetable production compared to before gher farming. Before gher had started, the farmers were not able to produce vegetables on the swamplands or paddy fields. The farmers have also planted both the long and short longevity fruit trees (Coconut, mango, guava, jackfruit, banana, papaya etc) on the dikes. The life cycle of prawn and carp is from May/June to December/January, *boro* paddy is from the end of January to end of April and seasonal vegetable is throughout the year. The cropping patterns of the area before and after are presented in figure 2.

Changes in Land Holding Patterns and Job Opportunity

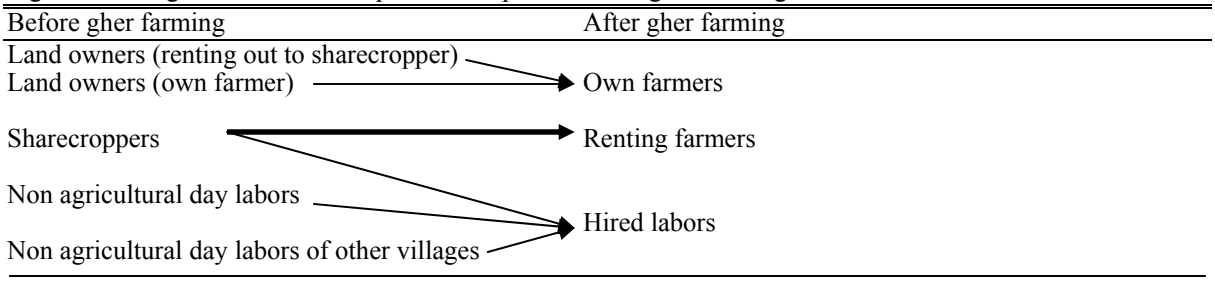
The change in land ownership patterns in the study area occurred by the gher farming is presented in figure 3. Prior to gher farming, about 80% of the landlords rented out all of their land to tenants on sharecropping basis, but with the introduction of gher farming system, landlords converted their paddy fields into gher farming. They now operate the gher themselves on their plots, which are close to their homes. However, in gher farming, it is difficult to operate several (gher) plots at the same time. Therefore, landlords still have to rent out their surplus lands even if the land is located close to their homes. The remaining 20% of landowners and small

Figure 2. Changes in Cropping Patterns after the Introduction of Gher Farming.



Note: ○ indicates the period up until the sowing paddy, and releasing of prawn and fish is carried out.
● indicates harvesting time starts.
Source: Field survey, 2003.

Figure 3. Change in land ownership and labor patterns after gher farming



farmers who used to cultivate their own land also converted their paddy field into gher farming.

Financially, the more stable sharecroppers prefer a fixed-period rental contract to operate gher farming, while the financially weaker farmers are unable to operate the ghers by themselves and work as hired labor in gher farming. Moreover, some of the non-agricultural day laborers, landless and marginal farmers of the study area also rent land from landlords on a rental contract basis. They are called renting farmers in gher farming system, also locally called *hari*. Since the landlords and nonagricultural day laborers now participate in gher farming system, the average farm size has become smaller compared to before gher farming. Change in contract system and share of family and hired labor due to gher farming system is presented in Table 1, which shows that the percentage share of hired labors in gher farming system has increased relative to local *aman* paddy production. About 42% hired labor was used in case of own farmers who cultivate local *aman* paddy (World rice statistics, 1995), whereas, about 60% hired labors is used in gher farming system (Field survey, 2003). In the sharecropping system, 100% labor was supplied from sharecroppers' families, whereas, only 33% labor was supplied from renting *gher* farmers' family. Therefore, gher farming system has created job opportunities for hired labor and has reduced family labor participation. Not only do the hired labor of the study area benefit from gher farming, but also the people of nearby villages.

Results and Discussions

Agricultural Income from Gher Farming

Costs, returns, profit, and agricultural income as well as household income of rice prawn *gher* farmers are discussed in this section. The cost items in gher farming includes prawn and carp fingerlings cost, various kinds of feed cost, labor, medicine, watching house cost, seed/seedling cost of paddy and vegetables, land preparation cost (bullock), irrigation, pesticides and fertilizer costs. On the return side, gross return includes revenue from prawn, fish, paddy and vegetables. The costs, gross revenue, and profit of agriculture are presented in Table 2, whereas household income of gher farmers is presented in Table 3.

Sources of household income

Rural households in developing countries derive income from various sources. Basically the agricultural households in developing countries earn income from three sources-profits from agricultural production, agricultural labor income, and off-farm

Table 1. Labor, land and output and the percentage share of labor used before and after gher farming according to contract system

Types of farming	Before			After		
	Labor	Land	Output	Labor	Land	Output
1. Land owner (Own farming)	Family (58%) Hired (42%)	Own	Aus, Aman	Family (40%) Hired (60%)	Own	Gher farming output are: Prawn, fish, rice and vegetables
2. Sharecropper	Family (100%) Hired (0%)	Sharecropper (Crop 50%)	Aus, Aman	Family (33%) Hired (67%)	Fixed land rent	
3. Landlord (Not farming)		Rent out	Aus, Aman	Family (40%) Hired (60%)	Own	

Source: World Rice Statistics (WRS) 1993-1994, and Field survey, 2002.
Note: Data of percentage share of labor for own farming before gher farming is based on WRS, 1993-1994, while data of sharecropper of local aman and after gher framing is from field survey, 2002.

Table 2. Production costs and returns of own and renting *gher* farming.

Particulars	Own farmer	Renting farmer
A. Variable costs of prawn and fish production:	(Taka)	(Taka)
1. Cost of prawn fingerlings	64,747	36,532
2. Cost of carp fish fingerlings	2,974	1,698
3. Feed Cost	97,957	45,053
4. Medicine Cost	3,417	2,227
5. (a) Labor cost (Permanent & temporary hired)	23,416	8,620
(b) Family labor cost	15,897	17,516
Sub Total	208,408	111,646
B. Variable costs of paddy and vegetables production:		
1. Paddy seedlings cost	2,784	1,630
2. Vegetables seedling cost	2,592	1,124
3. Land ploughing cost	1,713	886
4. Labor cost (hired)	8,713	5,331
5. Irrigation cost	1,598	1,000
6. Pesticides cost	1,515	829
7. Fertilizer cost	1,064	501
Sub Total	19,979	11,301
C. Total variable costs (A + B)	228,387	122,947
D. Fixed costs:		
1. Total *gher* cost:		
(i) Maintenance cost	12,258	6,600
(ii) Depreciation cost	1,691	866
2. Monitoring housing:		
(i) Maintenance/repair cost	754	479
(ii) Depreciation cost	615	456
3. Opportunity cost of land	37,234	0
4. Land rent	0	17,961
Total fixed costs	52,552	26,362
E. Total costs (variable and fixed costs) (C + D)	280,939	149,309
F. Revenue from prawn and fish:		
1. Prawn	385,893	199,975
2. Carp	21,658	12,371
G. Revenue from paddy and vegetables:		
3. Paddy	27,202	18,037
4. By-product of paddy	1,049	910
5. Vegetables	14,290	7,171
H. Total revenue (F + G)	450,092	238,464
I. Net profit (H – E)	169,153	89,155

Source: Field Survey, 2003.

Note: 1) 1 US$ = 58.50 Taka, October, 2003.

2) Average *gher* farm size of own and renting farmers was 1.65 and 0.95 hectare, respectively.

3) Depreciation of construction of *gher* and monitoring house were calculated by the straight-line method. In this method, depreciation is to divided total expected depreciation equally among the expected number years of the life of the *gher* (Hopkins and Heady, 1955). On the basis of the farm survey data, the economic life of *gher* farming was considered as 25 years.

activities. The agricultural profit is the sum of crop income, and income from livestock and poultry production. Likewise, agricultural labor income includes labor sold to other farms, and off-farm income can be decomposed into earnings from self-employment, wage received in rural non-farm labor markets, and remittances from household members working in urban areas (Renkow, 2000).

Table 3 provides information concerning income sources. The table shows that agricultural income remains the principal source of income for households in the sample—about 87% on average for

Table 3. Annual per household income of own and renting gher farming.

Particulars	Own farmer (31)	Renting farmer (31)
1. Agriculture:	(Taka)	(Taka)
(i) Gher farming	169,153	90,021
(ii) Livestock	1,274	1,452
(iii) Homestead gardening	2,310	1,532
2. Agricultural wage (male and female)	15,645	16,645
3. Off-farm income	5,900	5,161
Total household income	194,282	114,811

Source: Field survey, 2003.
Note: 1 US$ = 58.50 Taka, October, 2003.

own farmers and 78% for renting farmers. The amounts of agricultural wage, livestock income and off-farm income were roughly the same for own and renting gher farmers but the percentage share of total household income was different for both types of farmers. The agricultural wage accounts for 8% for own farmers while about 15% accounts for renting farmers, indicating that the percentage share of agricultural wage to total household income renting farmers is higher than the own farmers.

Annual per household income in rural areas in Bangladesh was Tk 57,792 in 2001 (BBS, 2001). The total household income for own farmers was Tk 194,282 and Tk 114,811 for renting farmers. The above figures indicate that per household average income of own and renting farmer was roughly more than three times and 2 times higher than per rural household income in Bangladesh, respectively. Therefore, it is concluded that the gher farming system has increased household income in this area than other rural areas of Bangladesh.

Comparison of Agricultural Income (*Gher *Farming to* Local *Aman)

As is shown above, the farmers in gher farming in the study area have gained in their agricultural income as well as in other household income. In this section, an attempt is made to determine the income gain from gher farming system by comparing it to other agricultural crops.

Before *gher* farming, the farmers produced local *aus* and local *aman* once a year. Therefore, the agricultural income (AIA) for sharecroppers is found as subtracting total cost (TC) from revenue (R), and add the opportunity cost of family labor (LC). Note that output is shared between landlord and sharecropper as half, but sharecropper carries all the production cost. Therefore, the agricultural income from local *aman* and local *aus* (AIA) per year for sharecropper is as follows:

$$AIA_S = \sum R_i - \sum TC_i + \sum LC_i - \frac{1}{2}\sum R_i;\ i = aman, aus$$

Also, AIA from local aman and local aus for landowner requires subtracting total cost (TC) from revenue (R), and adding the opportunity cost of family labor. Therefore, the agricultural income from local aman (AIA) per year for landowner is as follows:

$$AIA_L = \sum R_i - \sum TC_i + \sum LC_i;\ i = aman, aus$$

Due to unavailable of data on aus paddy, production cost and return from local *aman* paddy was used as a proxy for local *aus*. Note that the per hectare production cost and return of local *aus* and local *aman* are almost similar. The agricultural income from *gher* farming (AIG) per year is found as total net profit of *gher* farming system (See table 4).

Given the above result, the agricultural income ratio (AIR) of own *gher* farmer (O) to landowner (L) and renting farmer (R) to sharecropper (S) is:

$$AIR = \frac{AIG_l}{AIA_i}, \quad i = S, L;\ l = R, O;$$

The detail of each term is as follows:

R = Per hectare total revenue of local *aman* which included paddy and by-product
TC = Per hectare total cost of local *aman* which included seed/seedling cost, labor cost, irrigation cost, fertilizer cost and equipment cost.
LC = Per hectare labor cost of local *aman* included family and hired labor.

The results of agricultural income, and total revenue, and their ratios are shown in Table 5. For comparison, the data for local *aman* in Khulna district in 1994-95 was employed. Thus, the deflated production cost and returns are used in the present

Table 4: Per hectare production cost and return of local aman in 1994-95 of Khulna district and its deflated value in 2001.

Particulars	Local Aman	Deflated value
1. Seed/seedling cost	973	1,285
2. Labor cost	3,320	4,382
3. Fertilizer cost	1,097	1,448
4. Irrigation cost	2,500	3,300
5. Pesticides cost	459	606
6. Equipments cost	677	893
7. Total cost (TC)	9,025	11,914
8. Total revenue (TR)	14,385	18,989
9. Total profit (8-7)	5,360	7,075

Source: Bangladesh Bureau of Statistics (BBS), 1998.
Note: The production cost of local aman does not include land rent. Since total profit is equal to the total revenue minus total cost, the total profit includes land rent.

Table 5. Change in total revenue, and profit per hectare before and after gher farming.
(1) Comparison of sharecropper and renting *gher* farmer

	Before	After	
Farming system	Local *aman*	Gher farming	Ratio
(i) Total revenue	37,978	238,464	6.28
(ii) Agricultural income	3,925	89,155	22.71

(2) Comparison of own paddy farmer and own *gher* farmer

	Before	After	
Farming system	Local *aman*	Gher farming	Ratio
(i) Total revenue	37,978	450,092	11.85
(ii) Agricultural income	19,233	169,153	8.79

Source: Field survey, 2003 and BBS, 1998; and author's calculation
Note: Before gher farming, the farmers produce local *aus* and local *aman* once a year. Per hectare production cost and return of local *aus* and local *aman* are almost same. Calculation procedure of agricultural income from local *aman* :

Before gher farming system, the landlords rented out their land to tenant on sharecropping basis, where the output is split between landlord and tenant 50:50, and the sharecropper carried all production cost. In sharecrooping system, 100% labor was supplied from family, whereas, 58% labor was supplied from family in case of own farming (see table 1). Agricultural income from local *aman* is the sum of total profit of local *aman* and the opportunity cost of family labor. So, agricultural income of sharecropping system from local aman is calculated as follows:

AIA=(R-2*TC)+2*Family labor cost;

And, agricultural income of own farming from local *aman* is calculated as follows:

AIA=2*(R-TC)+2*0.58*Total labor cost;

Total labor cost, total cost (TC) and revenue (R) of local *aman* are (2), (7) and (8) respectively, of table 4.

study so as to compare them to field survey result in 2001. The production cost and return from local *aman* per year per hectare are presented in Table 4.

The result shows that the agricultural income for renting gher farmer is about twenty three times higher than sharecroppers' agricultural income from local *aman*, whereas, the agricultural income for own gher farmer is nine times higher than own paddy farmer. Therefore, change in agricultural income from gher farming has greater impact on renting gher farmer than own gher farmer. Total revenue of renting gher farmer was found to have be six times that of the sharecropper. On the other hand, total revenue of the own gher farmer was found to be about twelve times that of own paddy farmers. Thus, it can be concluded from Table 5 that the gher farming system has increased agricultural income for farmers, with greater increase in agricultural income for renting farmer than for own gher farmer in the study area.

Conclusions

The gher farming system is a very profitable enterprise compared to local *aus* and local *aman* paddy. Both the renting and owning gher farmers have gained in agricultural income as well as household income from gher farming as compared not only to local *aman* but also to rural household income in Bangladesh. After the introduction of gher farming in southwest Bangladesh the cropping patterns have changed. Prior to gher farming, the farmer cultivated only local *aus*, local *aman* and oil seeds but now the farmer produces MV *boro* rice along with prawn and carp. The land tenant system has changed from sharecropping to fixed cash rental. Prior to gher farming, the landlords rented out their land to tenants on a sharecropper basis but now the landlords rent out only the surplus land that they cannot utilize on their own. As a result, the landlords get cash from renting farmers, while the renting farmers can be actively involved in gher farming to make a higher profit. The results show that the gher farming system has increased agricultural income, which has led to a better living standard for the people in this area. All these reasons suggest a very positive impact of gher farming. The important findings of the study are that the rice prawn gher farming system has improved the standard of living even though the people of this village are still living below the poverty line. The present study has only discussed the impacts of gher farming on household income, landownership and cropping patterns. It is necessary to conduct further research of the impacts of rice gher farming on the environment in future for policy implication for the development of rice prawn gher farming in southwest Bangladesh.

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