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Article

Key Performance Characteristics of Organic Shrimp Aquaculture in Southwest Bangladesh

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Abstract: In Bangladesh, black tiger shrimp (*Penaeus monodon*; Fabricius, 1798) aquaculture has come to be one of the most important sectors in both the rural and national economies. Likewise, organic shrimp aquaculture has emerged as an alternative farming enterprise for farmers especially in the southwestern districts of Bangladesh. The present study aims to show key performance characteristics of organic shrimp farmers and farming in a prototypical shrimp farming area in Bangladesh. Data was collected in 2009 from organic shrimp farmers in the Kaligonj and Shyamnagar sub-districts through questionnaire interviews, transect walks and focus group discussions. The mean productivity of organic shrimp farming in the area is 320 kg ha^{-1} yr^{-1} (ranging from 120 to 711 kg $ha^{-1}year^{-1}$). Organic farmers are more likely to have a higher monthly income and less aquaculture experience. Moreover, suitable landholdings and classified labor distribution have been found to play an important role in the development of organic shrimp aquaculture. The most common assets of organic shrimp aquaculture are high yield, low production cost, available post larvae and high market prices. Small business farmers are likely to earn more income benefits from organic shrimp aquaculture than their larger-scale counterparts. Finally, the paper suggests that more research is needed to stimulate the success of organic shrimp aquaculture.

Keywords: organic shrimp; organic aquaculture; production; land; labor; Bangladesh

1. Introduction

Worldwide, aquaculture is dominating all other animal food-producing sectors in terms of growth. The sector has been growing at an average annual rate of 8.9% since 1970, compared with 1.4% for capture fisheries and 2.8% for terrestrial meat production systems [1]. Aquaculture has lagged behind the agriculture sectors in terms of both quantity and diversity of certified organic produce [1,2]. Organic agriculture is rapidly developing worldwide with 35 million hectares of agricultural land presently farmed, whereas in aquaculture only 0.43 million hectares of land are managed organically [3].

Consumer demand for organic produce is growing faster than supply [4]. The growth in global demand for organic foods is estimated at 20% per annum [5]. The growth rate of organic aquaculture products, however, is unknown, but estimates range from 20% to 30% annually [6]. In 2008, there were 225 certified organic aquaculture operations in 26 different countries, with an overall production amounting to 53,000 tons [7]. The production of organic aquaculture is predicted to increase 240-fold by 2030, *i.e.*, to an equivalent of 0.6% of the total estimated aquaculture production [1]. Organic aquaculture has attracted attention due to consumers' awareness about overfishing, environmental degradation, health risks, sustainability and animal welfare [8–10].

Organic aquaculture is a new concept, and remains under development; basic standards were drafted in 1998 by the International Federation of Organic Agriculture Movements [1,5,11,12]. However, the practice of organic aquaculture is ancient, especially in Asia and particularly in China. The EU is the pioneer in legislation for organic farming and a legislative framework for organic aquaculture was introduced in 2009 [13]. There are 20–25 private and non-private certifying bodies currently involved in the organic aquaculture sector. These certifying bodies manage a diverse set of aquaculture standards, which often vary considerably from country to country, certifier to certifier, and species-to-species [1]. Entrepreneurs such as retailers and supermarket chains have now introduced organic aquaculture products as a response to this increased consumer demand [14]. In Europe, 87%–93% of the certified organic aquaculture products come from marine and brackish water sources. Globally, organic aquaculture is limited to a few species, mainly shrimp, salmon, trout and carp [1,14]. Research on organic diets and nutrition is steadily progressed. Accessible information on organic diets and nutrition is not extensive for scientific reference. Sourcing suitable feed and the costs are major challenges for the organic aquaculture operation. Substitution of fish meal and fish oil is an important limiting factor impeding organic feed development. Organic aquaculture operations manage to reduce the dependency on capture fisheries and to reduce the feed costs [7,15].

In Bangladesh, shrimp, locally known as *Bagda*, has been attracting considerable attention over the last three decades due to its export potential for international markets. In the financial year 2007–2008, Bangladesh exported 49,907 tons of shrimp and prawn (*Macrobrachium rosenbergii*; De Man, 1879), valued at US$ 409 million, while the sector contributes about 4.04% to the total export earnings and 3.74% to the GDP [16]. The shrimp industry employs approximately 1.2 million people in Bangladesh for production, processing and marketing activities. Likewise, the well-being of 4.8 million household members depends on this sector [17]. Despite the export potential and the employment generated, shrimp aquaculture has incurred considerable environmental cost. Shrimp aquaculture has therefore been criticized by environmental and social scientists around the world especially in terms of unplanned expansion [18–20]. In southwestern Bangladesh, agricultural land and low-lying floodplains have been turned into *gher* (Bangladeshi local term for modified rice fields or ponds located beside canals or rivers that are used to cultivate shrimp and fin fish) systems for shrimp cultivation since the early 1970s [21]. These conversions have had adverse effects on the wetland ecosystems, and in addition to this ecological drawback, the intrusion of saline water into paddy lands has created social conflicts [19,22]. The remaining mangrove forests are under pressure due to the unplanned expansion of shrimp *ghers*, and continuous cutting, encroachment, storms and climate change [19,23]. Viral diseases such as the White Spot Syndrome Virus (WSSB) have caused huge economic losses in shrimp production of Bangladesh [24,25]. In addition to these problems, the sector has been facing many other issues, such as low yields, lack of adequate technology, price fluctuations in international markets, bans imposed by the European Union and lack of government stimulus [19,21,22,24,26]. However, the major importing countries' demand for quality and safe shrimp products has increased tremendously. It is these countries that set up strict standards and regulations to ensure quality and safety. As a consequence, organic shrimp aquaculture has been introduced to southwest Bangladesh as an alternative culture.

In 2005, an Organic Shrimp Project (OSP) was initiated in Bangladesh by the Swiss Import Promotion Program (SIPPO). This program is authorized by the Swiss government to promote small and medium enterprises from developing and transition countries through consulting, training, marketing support, and facilitating access to trade fairs. According to the memorandum of understanding between Bangladesh Frozen Food Exporters Association (BFFEA) and SIPPO, signed on 6 December 2004, SIPPO is involved in training farmers and processors for producing organic shrimp in Bangladesh. SIPPO facilitates the necessary contracts for imports into Switzerland and the European Union, and promotes organic products in Bangladesh. This project was implemented in collaboration with the national NGO *Shushilan*. SIPPO closed their activities in 2007, because the program's focus shifted from South Asia to Eastern Europe, Africa and Latin America. The service-providing organization, Euro Centra (a member of Wünsche business group), took over the responsibilities for the OSP in the same year, but discontinued activities in 2007. As successor, the Germany-based importing organization, WAB-Trading International, continued the OSP operations, with Gemini Sea Food Ltd. as the processor. Now, the organic farms of the OSP are certified by Naturland, a German private organic farmers association that runs an aquaculture scheme. The farmers' compliance with the private Naturland scheme is inspected by the Institute of Market Ecology (IMO), an international certification body inspecting and certifying various schemes related to eco-friendly products, accredited by the Swiss Accreditation Service according to EN 45011/ISO 65 [27]; Naturland being an organic farmers' and processors' association pioneering the development of several private standards for organic farming, including for aquaculture, to be inspected and certified by third party certifiers like e.g., IMO. Naturland is the pioneer in organic shrimp; the pilot project was initiated in Ecuador in 1999, and from there, OSPs have spread to Vietnam, Indonesia, Thailand, Peru and Bangladesh [1].

Various criteria need to be followed by Naturland certified organic operations. For example, approximately 50–70% of the total dyke surrounding the *gher* must be covered by natural vegetation. Culture techniques must be extensive and a very low stocking density (<15 post larvae/m^2) is required. The farmers are allowed to release only native shrimp post larvae from nominated nurseries. The nurseries have to collect hatchlings from hatcheries located in Cox's Bazar, which is in southeastern Bangladesh. There are about 57 private and two government powered shrimp hatcheries in Bangladesh [28]. The collected hatchlings are required to be antibiotic-free and the quality of the hatchlings must be monitored by an external consultant. Other native shrimp species come from the wild via water exchange, although this is controlled strictly using fine sieves in the pipe inlets. The shrimp nourish themselves on natural food produced from processed cow dung or compost. No additional feeding and chemical fertilizers are to be used by the farmers. The shrimp are grown following traditional systems, which use the tides to control the water quality and to harvest the *ghers*. In this method, farmers stock post larvae 8 to 10 times during a full production cycle. Every *gher* must have small ditches inside the *gher* to acclimatize the post larvae before they are released to the main *gher*.

Thus, the organic shrimp production system has come to be comparatively elaborate, and functioning certification and marketing bodies have been established. Nevertheless, in Bangladesh, neither organic aquaculture nor organic shrimp farming have so far been addressed by scientific research. The purpose of this paper is to understand why organic shrimp aquaculture is expanding in Bangladesh and who is getting more benefit. The hypotheses of this paper that characterization of farmers performance can inspire the adoption of organic shrimp farming. The aim of this paper is to show how shrimp farmers perform organic practices and to identify key performance characteristics considering land and labor distribution in a study site prototypical for aquaculture in Bangladesh.

2. Methods

The study was conducted in the Satkhira district, a salinity-affected coastal area of the Bay of Bengal, situated in southwestern Bangladesh (Figure 1). The SW regions of Bangladesh (Khulna, Bagerhat and Satkhira districts) are operating eighty percent of the country's shrimp farms [29,30]. Satkhira has been identified as the most promising area for brackish water shrimp culture due to year-round moderate to high water salinity [31]. Mostly, shrimp is cultivated in this area between February and November when the water of the surrounding rivers becomes saline. The dry season is from November to February; with its high water salinity and scarcity make it hardly suitable for shrimp cultivation. During summer monsoon, from July to October, some farmers grow rain-fed transplanted rice as the overall salinity becomes low [32]. Satkhira district is divided into seven sub-districts. Among them, only Kaliganj and Shyamnagar sub-districts have been considered in this study, because there are a large number of shrimp farms are operating in the area due to the available saline water and the closeness to the river channels. Both sub-districts are located close to the world's largest continuous mangrove forest. Here, an OSP is implemented by WAB trading international. The OSP has about 200 staff members whose education levels vary from secondary to doctoral degrees. Most of the staff members are local farmers. The OSP works according to an "internal control system" (ICS). The ICS includes internal quality management procedures, internal training, and internal inspections done by the staff as a means to prepare for the external, independent, third-party inspection by IMO. The internal trainers cannot be an inspector and vice versa.

Data was collected between October and December in 2009 during the late harvesting season. This study applied both quantitative and qualitative data collection methods which are used by the following authors, e.g., Ahmed *et al*. [33]. Research was done in collaboration (to help identifying the respondents) with WAB Trading International. WAB cooperates with 160 organic farmers' groups (15–40 per group) and 3,379 individual organic farmers. From these 160 groups, 12 per sub district were selected through a stratified random sample (stratum = sub-region). In every group, farmers were again selected through stratified purposive random sampling based on the strata *gher* size (small, medium and large) (Table 1). A total of 144 organic shrimp farmers, 24 in each stratum from each sub-district, were sampled.

Figure 1. The study areas Kaliganj and Shyamnagar in SW Bangladesh (Sathkira district) (Source: Banglapedia—the National Encyclopedia of Bangladesh, 2003) [34].

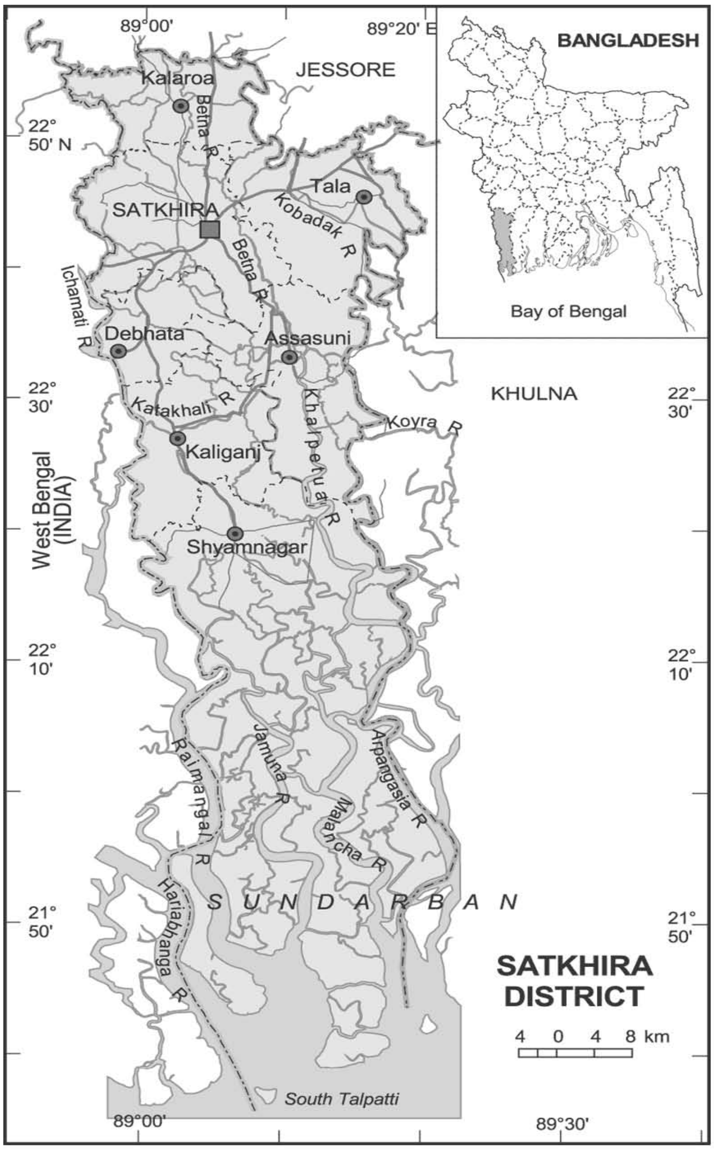

Table 1. Categories (farm size) and sample size of shrimp farms and their distribution in the study areas Kaliganj and Shyamnagar (Bangladesh).

Farms category	*Gher* size	Sample size (farms) Kaliganj	Sample size (farms) Shyamnagar
Small farms	≤0.67 ha (≤5 bighas *)	24	24
Medium farms	0.68 to 2.00 ha (5.1 to 15 bighas)	24	24
Large farms	≥2.01 ha (≥15.1 bighas)	24	24

* The *bigha* is a unit of measurement for an area of a land in Bangladesh (1 ha = 7.48 bighas); *: the meaning of bighas.

Primary data was collected during a face-to-face field survey using a pre-tested questionnaire. Pre-tests were done on 14–16 October with 6 non-sampled shrimp farmers. The questionnaire contained both pre-coded and open-ended questions. The questionnaire was developed in English and then translated into Bengali by the first author to ensure efficient communication with farmers during interviews. Each respondent was given a brief introduction about the nature and purpose of the study before the interview commenced. Then the questions were asked in sequence, with replies being recorded directly onto the questionnaire. For each interview, the time required was about 40 minutes.

As a means of triangulating the data derived from questionnaires, several topics relevant to the study such as farmer's views and experiences in shrimp culture activities, where presented and discussed in focus groups [35,36]. A total of 8 focus group discussions were conducted in both sub-districts. Each focus group session comprised 8–12 individuals and the duration of each discussion was approximately an hour. Focus group discussions were conducted only with organic shrimp farmers. The discussions were recorded with a digital voice recorder, and organized with the help of WAB staffs (identification of convenient venues and time). The focus group discussions were held inside collection centers of WAB and in farmer's residences. During the discussion, the first author of this paper acted as moderator of the sessions. WAB staff was not present during the focus groups.

In addition, 10 transect walks [37] were performed systematically with shrimp farmers by walking across the *gher* sites at the beginning of the study to build rapport. Transect walks allow researchers to speak and observe with farmers directly at the sites relevant to the research [38]. Thus, they provided informal information on resource use patterns and helped to understand the farming practices and daily livelihood activities. The experiences from the transect walks were also useful for validating farmers' answers from the questionnaires.

Questionnaire interview data were coded and entered into a database system using MS-Access (Microsoft 2003). The statistical package for social science (SPSS 15.0 for Windows) was used to produce descriptive statistics. Comparisons among farmer's categories were made by ANOVA F-test and Spearman correlation. The ANOVA was followed by a Tukey Post-hoc comparison of means. Differences are reported as significant at a level of $p \leq 0.05$. In some cases, data was normalized using the log transformation.

All results presented in this paper in the results section about "farmers" refer to organic shrimp farmers.

3. Results

3.1. Socio-Economic Characteristics of Shrimp Farmers

The studied farmers are on average 41.9 years old, ranging from 19 to 82 years (Table 2). The mean household size of the farmers' families is 5.6 persons, ranging from 2 to 16. This is slightly higher than the national average of 4.9 from census data of 2001 [39]. Among the farmers, 15% are illiterate, while 85% have a formal education. Larger farmers stayed significantly longer at school than smaller farmers. On average, farmers have 14.4 years' experience working with shrimp. Smaller farmers have significantly less experience (in years) than medium and large size farmers. The monthly income of organic farmers is US$ 477.9 on average (Table 2), and is significantly higher for larger farmers than for small and medium size farmers.

All farmers have more than one livelihood activity. Of the total farmers, 83% consider shrimp farming as their main activity and primary source of income, followed by 8% of the farmers seeing business, and 4% seeing agriculture as their main activity. Altogether, 17 % of the farmers have earned money from shrimp farming as their secondary activity and source of income. Livelihood activities such as business (26%), shrimp purchasing and selling (19%), agriculture (13%), and agricultural day labor (11%) occur as secondary sources of income for the farmers. Several of these occupations offer neither full-time employment nor food security. Thus farmers rely on multiple sources of income.

Table 2. Socio-economic variables (Arithmetic mean, standard deviation in parenthesis) of surveyed respondents (n = 144).

Variables	Small farms	Medium farms	Large farms	All farms	Standard error	F-statistics	Significance level
Age in years	40.1 a (13.1)	42.5 a (12.9)	43.3 a (9.1)	41.9 (11.8)	0.989	0.944	ns
Household size in number of persons	5.0 a (2.1)	6.1 a (2.5)	5.6 a (2.6)	5.6 (2.4)	0.205	2.377	ns
Years of school attendance	6.1 a (4.5)	6.8 ab (4.1)	8.4 c (3.9)	7.1 (4.3)	0.359	3.827	*
Experience with shrimp farming in years	9.6 a (4.0)	15.7 bc (4.5)	17.9 c (5.9)	14.4 (6.0)	0.501	36.190	***
Monthly income in US$#	161.4 a (76.7)	287.3 ab (204.3)	984.9 c (884.5)	477.9 (636.3)	53.030	34.137	***

Statistical tests based on transformed data. Values of mean given untransformed. Significance level: * = $p \leq 0.05$; ** = $p \leq 0.01$; *** = $p \leq 0.001$; ns = not significant; a, b, c: Different letters indicate significant differences at $p \leq 0.05$. # US$ 1 = Taka 70 in December 2009 (Taka = Bangladesh currency).

3.2. Land and Labor Distribution

Of the farmers' total land holdings, 70% are used for organic shrimp production, followed by 19% used for agriculture activities. Eight percent of the land is used for homestead purposes where farmers construct their houses. Recently, homestead land has often been used by the farmers for producing rice and vegetables because of a lack of agricultural land. Three percent of the land is used as ponds for producing fish. On average, each organic shrimp farmer owns 1.24 ha of land (Table 3).

Table 3. Distribution of total owned land, arithmetic mean, standard deviation (SD) and percentage in terms of land use pattern of the respondents (n = 144).

Land use pattern	Total own land (ha)	Mean	SD	Total own land (%)
Shrimp farming	140.80	0.98	1.47	70
Agricultural land	37.44	0.26	1.07	19
Homestead land	15.73	0.11	0.11	8
Ponds	5.79	0.04	0.07	3
Total	199.76	1.24	1.87	100

The land used as *gher* consists of owned, leased-in, and leased-out land. The total *gher* area of all interviewed farmers is 333.86 ha; however, non-sampled farmers related to WAB are keeping more than 4,000 ha of land under organic shrimp farming. Large business farmers take up 77% of the total land area for *gher* operation, while only 6% of the area belongs to small business farmers. The average size of *gher* under organic shrimp production is 2.32 ha (as opposed to conventional shrimp farming with 2.28 ha) [22]. The mean *gher* size for shrimp production of larger farms is 5.37 ha, followed by medium (1.17 ha) and small (0.43 ha) farms.

Of the total farmers, 78.5% own land for the use of *gher*. About 21.5% do not own any land for shrimp farming, but they are operating *gher* for shrimp production as lease-in or participate in a jointly managed *gher*.

Of all farmers, 82.6% do not lease out their land, meaning that they operate their *gher* themselves. Nevertheless, 71.5% of organic farmers take lease-in land from their neighbors to pursue shrimp farming. In comparison to small and medium size farms, larger farms perform shrimp farming on larger size plots of owned land and they also lease in larger size plots (Table 4). Leasing periods vary from one to five years. Leasing values depend on location and vary from US$428 to $748 $ha^{-1}year^{-1}$.

Table 4. Distribution of mean land size (ha) according to tenancy pattern of *gher* by farmer's category (n = 144).

Land tenancy pattern	Small farms	Medium farms	Large farms	All farms	Standard error	F-statistics	Significance level
Owned land (ha)	0.29 a (0.28)	0.64 ab (0.51)	2.01 c (2.13)	0.98 (1.47)	1.226	24.203	***
Leased-in land (ha)	0.18 a (0.22)	0.56 ab (0.46)	3.65 c (4.84)	1.46 (3.19)	0.266	22.004	***
Lease-out land (ha)	0.04 a (0.14)	0.05 a (0.13)	0.29 a (0.95)	0.13 (0.56)	0.047	3.077	ns

Values of mean given untransformed. Standard deviation in parenthesis; Significance level: *** = $p \leq 0.001$; ns = not significant; a, b, c: Different letters indicate significant differences at $p \leq 0.05$.

Shrimp farming uses a combination of family and wage labor. Shrimp farms require labor for various activities such as *gher* preparation (drying, clearing and leveling of land, trench excavation and levee construction, liming, manuring, letting in saline water), carrying and releasing post larvae, weeding, guarding farms and harvesting, transporting and marketing shrimp and fish. All such work is seasonal or semi-permanent. On average, 1.38 persons per family are involved for *gher* preparation such as drying *gher*, liming, manuring, entering saline water, *etc*. *Gher* preparation is seasonal work and the farmers employ daily-paid workers as casual workers or on a work contract basis. Most farmers hire wage labor to construct *gher*; on an average, 4.51 persons per production cycle hire during *gher* preparation work. Wage labor for *gher* preparation is mostly used for heavy work such as clearing and leveling of land, trench excavation and levee construction. Mostly, family labor is directly involved in taking care of the *gher*. *Gher* care by hired laborers is performed by an average 0.69 persons per respondent. The pertinent correlation value (r) confirms the association between the amount of labor used for different purposes and farm size. The larger the *gher* area, the lower is the possibility of involving only family members. The larger the area used for *gher* operation, the larger is the likelihood of hiring wage laborers for *gher* preparation and maintenance (Table 5).

Table 5. Relationship between labor use pattern and farm size (n = 144).

Labor use pattern with purposes	Persons involved in mean	r value
Family labor involved for *gher* preparation	1.38 (0.036)	−0.551 ***
Wage labor involved for *gher* preparation	4.51 (0.089)	0.437 ***
Wage labor involve for taking care of gher	0.69 (0.013)	0.726 ***

Significance level: *** = $p \leq 0.001$. Standard deviation in parenthesis.

3.3. Perspectives for Organic Farming

Organic shrimp production is monitored by WAB, and all organic farmers have an identification number supplied by WAB. No farmer can sell shrimp to WAB-established collection centers without showing this identification number. All farmers reported that the prices of organic shrimp are comparatively higher than conventional shrimp. The average prices of shrimp from conventional aquaculture in local markets varied from US$5 to US$7/kg, while WAB-nominated processor Gemini offered one dollar more than the local markets for organic shrimp. The prices of organic shrimp are paid in national currency (taka). Almost all farmers get training on organic shrimp farming activities from WAB and each farmer has received training at least three times for 2–3 hours each.

Organic shrimp aquaculture depends on the availability of post larvae. Two types of post larvae are available in Bangladesh: natural post larvae and hatchery post larvae. Only one designated hatchery is allowed to supply hatchlings to local nurseries using air transportation. This does not stress hatchlings as much during the long journey from southeastern to southwestern Bangladesh. The estimation of the annual production of shrimp post larvae from hatcheries in Bangladesh is more than 5 billion [27]. In considering 144 organic shrimp farmers, they required approximately 1.6 million post larvae to stock in their *gher*, which is only 0.03% of the total annual production. Currently, organic shrimp farmers are stocking the rate of 1−2 post larvae/m^2, which is much lower than the recommended density by Naturland. Seventy-nine percent of farmers reported that natural post larvae are hardly available (often not found due to scarcity), and 14% claimed moderate availability (often found, but not in high enough quantities). On the other hand, 94% of the farmers stated that hatchery post larvae are sufficiently available for shrimp cultivation.

The mean yield of organic shrimp is 319.61 kg/ha/year (Table 6). The shrimp yield of small business farmers is higher than that of medium and large businesses. Seventy-six percent of farmers do not stock prawn in *gher* due to high salinity, and the remaining farmer's stock prawn during rainy season only. Medium business farmers produced higher prawn yields compared to small and large businesses. Most fish and others (different shrimp species) found in *gher* enter during water exchange, although few farmers stock them. Large business farmers harvest higher yields of fish and other kinds of shrimp species compared to medium and small businesses. Farmers of all categories benefited from shrimp farming, be it from shrimp yield or from the combination with fish and others.

Aquaculture activities (including shrimp, prawn, fish and other kinds of shrimp species) generated more than 75% of the total annual income, and shrimp alone generated about 63.3%. In comparison to other aquaculture items, shrimp contributes significantly to the income, because this species is exported and the farmers earn foreign currency. Income from shrimp as compared with the share of fish and others is significantly higher for large businesses than for medium and small ones. Farmers earn 10.2% of their income from fish and other kinds of shrimp, the major share belonging to large business farmers. Income from agriculture is 3.8% of the total income. Of the total incomes, 12.1% of earnings come from other sources and 7.7% come from business sectors (shop keeping and petty trading) (Table 7). Other sources of income such as foreign remittances, pension, laborers' wages, *faria* (local agents buy shrimp from farmers and sell them to depots or processor), rickshaw or van puller wages jointly contribute to the second largest portion of the income.

Table 6. Yield (arithmetic mean, standard deviation in parenthesis) of different species (n = 144).

Variables (Yield)	Small farms	Medium farms	Large farms	All farms	Standard error	F-statistics	Significance level
Shrimp (kg/ha/year)	431.47 a (133.38)	261.97 bc (93.52)	265.40 c (104.48)	319.61 (136.42)	11.368	36.091	***
Prawn * (kg/ha/year)	23.25 a (13.37)	34.72 ab (16.23)	18.49 c (15.32)	25.49 (16.21)	2.739	3.665	*
Fish & others (kg/ha/year)	115.29 a (55.02)	152.74 ab (85.84)	271.32 c (133.53)	179.78 (9.77)	9.765	33.847	***

Values of mean given untransformed; Significance level: * = $p \leq 0.05$; *** = $p \leq 0.001$; a, b, c: Different letters indicate significant differences at $p \leq 0.05$. * Prawn (*Macrobrachium rosenbergii*).

Table 7. Percentage distribution of total annual income from different sources distinguish by farmers category (n = 144).

Source of income	Small farms	Medium farms	Large farms	All farms	Significance level
Shrimp	51.3	48.8	69.5	63.3	***
Prawn	0.8	1.7	1.0	1.1	**
Fish and others	2.7	5.9	12.7	10.2	***
Agriculture	2.6	9.7	2.3	3.8	ns
Livestock	1.2	0.8	0.3	0.5	ns
Business	7.9	10.4	6.9	7.7	***
Job	1.8	5.4	0.0	1.3	*
Other	31.5	17.3	7.3	12.1	ns
Total	100.0	100.0	100.0	100.0	

Significance level: * = $p \leq 0.05$; ** = $p \leq 0.01$; *** = $p \leq 0.001$; ns = not significant.

Shrimp are harvested twice every month from April to November. The timing of the harvest in its seasonality is linked to the lunar cycle. Shrimp are trapped with a local tool called *Atol* (trap made from bamboo). Shrimp harvesting is done starting at the full and new moon, respectively, and continues for five to seven days. Trapped shrimp are collected every morning and kept in aluminum or plastic containers.

Eighty percent of the organic farmers revealed that the yield of organic shrimp has increased as compared to their previous experience with conventional shrimp farming. According to FGD participants, the yield has increased, because organic farmers' *ghers* are not affected by shrimp diseases (e.g., white spot and yellow head, *etc*.). Overall mortality of post larvae in each restocking are decreased due to maintaining low stocking density. The increases of yields are not quantified by the farmers, although they recognize the increase of yields comparing their earnings from past years.

Ninety-one percent of the organic farmers stated that production cost has decreased tremendously, since they do not use fertilizers, additives, supplementary feeds or vitamins any longer. Organic farmers depend on processed cow dung, compost and the exchange of natural water to maintain water quality. Ninety percent of farmers exchange water from natural sources and 10% do not exchange water because they do not have the necessary facilities. The sources of saline water are river and canal. The distance to a saline water source varied from 10 meters to 3 kilometers. The tidal flows of saline water are regulated by the sluice gates. Most farmers receive post larvae from nurseries on credit, because they usually negotiate payment to take place after harvest started. Farmers can only restock post larvae having paid the earlier delivery.

4. Discussion

Farmers of organic shrimp in Bangladesh tend to be younger, hold an academic degree, and have less aquaculture experience and a high monthly income. This profile is quite different from conventional shrimp aquaculture study in Bangladesh [40]. Many studies from different countries have reported organic agriculture farmers with high levels of academic education, to be younger, have less farming experience and urban backgrounds [4,41,42]. Similar notions are echoed in consumer studies in that households with high levels of education and income are more likely to purchase organic foods [14,43,44]. Education and experience can play important roles in transforming information to enhance knowledge and skills, and in inspiring to choose appropriate technology [20]. Lower levels of education, less experience and lower income availability can affect farmers' capacities to adopt new technologies like organic shrimp aquaculture. Most shrimp producers are locally settled and have little or no information about organic aquaculture. Lack of information and the necessary skills can be a major barrier to the adoption of organic agriculture [1].

The motivations for organic shrimp aquaculture production in Bangladesh are linked with suitable landholdings, labor forces, higher yields and higher market prices. The average farm sizes of organic and conventional shrimp farms are quite similar in the southwest region of Bangladesh. This has happened because the same types of farmers have converted from conventional to organic. In contrast, the average size of organic farms is smaller than that of conventional farms in Western countries [4,45,46]. More recently, however, organic crop farmers in Norway tend to have larger farms than their conventional counterparts [42].

The distribution of landholdings is skewed towards large *gher* owners for organic shrimp aquaculture. Similar results are found with conventional shrimp farmers in Bangladesh [47]. Most farmers rely on combining owned and lease-in land for organic shrimp aquaculture. Conventional and integrated farmers also depend on owned and lease-in land for cultivating shrimp in Bangladesh [40,47]. Currently, organic farmers are not interested in leasing-out their land. Perhaps they recognize that organic farming is environmentally friendly and less prone to production failures. Small business farmers have leased-out their land because it is difficult for them to provide the needed investment for *gher* preparation and stocking shrimp post larvae. In some cases, small business farmers migrated to other locations to earn hard cash in order to manage their daily livelihoods. In addition, small business farmers' land is situated often inside large *gher*. In these cases, small business farmers might increase their *gher* size and see their only opportunity in selling or leasing out their land to large neighboring property owners. All organic farmers are native inhabitants. There is no outside farmer performing organic practices these days. Earlier on, however, during the initial stages, when shrimp farming expansion took place in a conventional manner, outside farmers would control shrimp aquaculture [47].

Organic farming is basically labor-intensive because it is not utilizing heavily mechanized growing techniques [48]. Distribution of labor force plays an important role in the Bangladeshi shrimp sector [47,49]. In Bangladesh, organic shrimp farming relies on labor work and there is no special training required for the laborers to handle shrimp. According to the FGD participants, organic farming required more laborers than conventional farming. The OSP is establishing and implementing labor rights and equal payment for both men and women. Organic agriculture farms provide health benefits to laborers as synthetic chemicals are not allowed in this farming system [48]. Family labor is fully involved in shrimp farming especially for taking care of *gher*. With large business farmers, family members do not participate in *gher* preparation. Perhaps their income is enough and they do not wish to partake in the hard work as laborers. The social structure in Bangladesh is such that a family with a good financial position would not perform hard labor. Therefore, most of the large business farmers depend on hired wage labor to taking care of the *gher* because they are involved in other income-generating activities. Hiring wage labor by all categories of organic farmers creates employment for the poor in every production cycle. The financial capacity of small business farmers to hire wage laborers has increased due to organic farming. The number of permanent labor contracts as given by large business farmers has increased also (e.g., organic farming disallows child labor; for stocking natural post larvae). In contrast, during rice cultivation, only large landlords were the major employers of the poor to manage rice fields [47].

The survey recorded a mean yield of organic shrimp of 320 kg/ha/year, ranging from 120 to 711 kg/ha/year. The certified organic shrimp yield is 227 kg/ha in Indonesia and Vietnam (recorded on 2 farms) and 2,000 kg/ha in China (1 farm) [9]. The highest production of certified shrimp is found in Thailand, 3 tons per hectare from Sureerath farm [6]. The high variation in yield of organic shrimp might be due to different production pattern intensities and a lack of technological knowledge. The Chinese and Thai certified organic shrimp farms probably came from zero water exchange systems, which are supposed to be not feasible in Bangladesh. Considering Bangladesh climatic conditions, it might not be possible to achieve as great a yield as China and Thailand. Intensification in organic shrimp farming is completely reverse to the ideas around organic certification restrictions. Farmers can diversify their culture techniques by considering multi-trophic layers of food and to improve husbandry conditions, which could offer better results in the future. The yield of organic shrimp is comparatively higher than that of conventional shrimp in Bangladesh. Various authors have reported different yields for conventional shrimp such as 260 kg/ha/year [50]; 146 kg/ha/year [24]; 80–200 kg/ha/year [51] in Bangladesh and 91–250 kg/ha/year in India [52]. Organic aquaculture practice has increased the shrimp yield, which directly influences the producers in Bangladesh to shift from conventional to organic.

The yield of organic shrimp is comparatively higher for small rather than for large business farmers and similar results are reported for conventional shrimp aquaculture [51]. This has happened due to small areas, low stocking density, easy management and low mortality. The owners of small *gher* take more care intensively; they perform water exchange for four to six days at the full and new moon every fortnight, and do weeding frequently. They used adequately processed cow dung and compost more frequently than large *gher* owners. Large business farmers get less production in shrimp, probably due to higher production of fish, the presence of other shrimp species and of a high number of predatory fish, which feed on substantial amounts of shrimp. Large business farmers are unable to exchange water quarterly because of farm size. Large business farmers can separate inlets and outlets by developing modern drainage systems to maintain adequate water exchange. Large business farmers can form cluster units within *gher* to attain higher production. Small business farmers strive to use fine sieves in their pipes when they exchange the water. This carefulness directly protects their shrimp harvest from predatory fish and undesirable shrimp species that might enter the *gher* with the natural water.

Globally, the demand of organic products is increasing robustly and sales have increased to over five billion US$ [53]. Organic shrimp farming is attractive for developing countries due to high prices and protection of environment and biodiversity [9]. Nevertheless, organic shrimp has no local market in Bangladesh. Farmers depend on exports and marketing of organic shrimp is a big concern for farmers. The major market for certified organic shrimp is limited to western countries like North America, Europe, Australia and Japan [9] and the choice of exporters is quite limited. Farmers get comparatively higher prices when WAB-nominated processors purchase shrimp directly from farmers in different collection centers. This has a direct influence on the increase of income for organic shrimp farmers. The price of organic shrimp depends on demand, but is also influenced by size, seasonality. A premium price is important to sustain the organic production [54]. An increasing number of consumers are willing to pay premium prices, which enables the farmers to reduce the economic and environmental pressure on production costs [55].

Organic farming is generating employment and promotes local resources as well as locally adapted production methods [48,56]. In Bangladesh, organic shrimp aquaculture has generated substantial employment for educated people, as well as ensuring several diversified working opportunities. According to FGD participants, women are employed in the *gher* of organic farmers, especially for removing weeds and clearing embankments. Various new types of working opportunities have been generated by the shrimp industry, such as production of bamboo-made screens, traps and baskets, net making, sluice gate building, cock-sheet box supplying, post larvae trading, van pulling, *etc*. Various industries such as hatcheries, nurseries, ice plants and processing plants have been established, centering on shrimp cultivation [57].

Organic farming allows antibiotic-free hatchery post larvae to cultivate in *gher* system. Hatchery post larvae are reared locally to ensure their better adaptation to site-specific conditions, and then they are distributed to farmers according to demand. Organic farming does not allow the use of natural post larvae, because of its negative impact on the local biodiversity [58]. The rate of mortality in shrimp post larvae is higher when shrimp seeds are harvested from estuaries and coasts using a variety of fine-mesh hand-held push nets [59,60]. Natural aquatic biodiversity is reduced due to shrimp post larvae collection because harvesters waste 12–551 post larvae of other shrimps, 5–152 post larvae of finfish, and 26–1,636 post larvae of other macro-zooplankton during the collection of a single shrimp post larvae in Bangladesh [58]. Usually women and children exclusively harvest shrimp post larvae from estuaries and coasts in Bangladesh. The Bangladesh government has already banned the collection of natural post larvae from canals or river channels [29].

Conventional aquaculture is often criticized for environmental degradation such as habitat destruction, waste disposal, exotic species and pathogen invasions, huge requirements of fishmeal, and fish oil to produce aquatic feed [61–63]. The method of organic shrimp aquaculture has lowered production costs, as fertilizers, supplementary feeds, feed additives and hormones, antibiotics, *etc*. are not allowed. This method is also environmentally friendly and decreasing production cost, in another sense it is contributing to reducing CO_2 emissions by not using fertilizers and feeds. Organic shrimp farming uses 30−40% less energy than conventional practices do [6].

Despite its advantages, global organic aquaculture production is lagging behind due to the absence of universally accepted standards, accreditation criteria and third-party certification [1,9,64]. Naturland was the first to develop the organic aquaculture standards that are applied in Bangladesh and are closely monitored by the WAB ICS team. In Bangladesh, farmers are not involved in the standard development process and they comply with Naturland standards. The standard developed by Naturland always promoted the use of local resources in organic farming and in this way; local knowledge has not been marginalized. OSP paid the cost of organic certification in favor of farmers. However, it may not be possible to export organic shrimp from Bangladesh to different countries applying similar standards, until multiple inspection and certification bodies work together creating one standard for all.

5. Conclusions

According to the investigated organic shrimp farmers, the prospects for organic shrimp farming in Bangladesh are positive. Nevertheless, the future of organic aquaculture depends not only on the farmers, but also on government stimuli, publicity, technological improvements, diversified marketing opportunities, premium prices, country-specific standards and consumer demand. Organic shrimp farming in Bangladesh has recorded high yields, but still it is low-yielding compared to other shrimp producing countries. The promotion of best management practices and/or good aquaculture practices can be good options for OSP to improve the yield in Bangladesh. Organic shrimp aquaculture will benefit from the adoption of an ecosystem approach [65], which will depend on governance and social issues. An ecosystem approach requires the combined action of scientific bodies, policy makers and sustainable management [65]. Empowerment of the farmers and enforcement of regulations within OSP can play a significant role in enhancing the sustainable development of the organic aquaculture sector. Theerefore, more research efforts are required to improve the yield and success of organic shrimp farming.

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