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Present status of integrated aquaculture in some selected areas of Nilphamari District in Bangladesh

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Abstract
A yearlong study was conducted to observe the present status of integrated aquaculture in Nilphamari district of Bangladesh. Data were collected from 76 farmers using a questionnaire. Three different types of integrated aquaculture systems were observed: rice-fish culture (46%), fish-horticulture (33%), and fish-poultry culture (21%). Fishes were cultured in polyculture systems. Banana, papaya, vegetables etc. were planted in pond dikes. Other important findings were: age of most farmers (76%) - between 41 and 60 years, the highest percentage of educational qualification - class eight (40%), trained farmers (66%), and average farm size - 0.29 ha. Major problems were low water retention capacity of the soil, lack of quality seeds, lack of capital, high labor cost, insufficient extension services etc. Integrated aquaculture practices were at the preliminary stage in the study areas. Therefore, the socio-economic conditions of the farmers can be uplifted by adopting improved farming systems through integrated approaches.

Keywords: Survey, integrated aquaculture, rice-fish, poultry-fish, Nilphamari district, Bangladesh

1. Introduction
The Bangladeshi are commonly referred to as '*Macche-Bhate Bangali*' (i.e., the people made of fish and rice). Rice and fish are the integral part of the socio-cultural heritage of the Bengali from the time immemorial. The demand for rice and fish is continuously increasing in Bangladesh as three million people assimilate to the population each year (Chowdhury, 2011) [9]. On the other hand, land and aquatic resources like ponds, *beels* etc. are declining day by day due to both anthropogenic activities and natural causes such as the construction of buildings, roads, industries, soil erosion etc. It is estimated that the annual reduction of arable land is about 1% in Bangladesh (Islam and Hassan, 2011) [17]. Therefore, two types of pressures are mounting on the land such as (i) increasing the population and (ii) declining the per capita land. On the other hand, annual fish demand for consumption is increasing, and the projected demand is 31 kg per capita by the year 2050 (Mukherjee *et al.*, 2011; Merino *et al.*, 2012) [29, 25]. In particular, fish is obtained from two sources for human consumption: capture fishery and aquaculture in Bangladesh. Aquaculture production has been increasing since the last 3-4 decades, while the yield of capture fishery is declining due to a series of factors such as overfishing, environmental degradation, pollution, habitat destruction, sedimentation and tidal control projects (Anka *et al.*, 2013) [5] that are hardly possible to reverse. Therefore, more attention should be focused on technologies that can provide not only fish but also crops and livestock for the food security of the growing population in the country.
In this regard, integrated aquaculture (the production, integrated management and comprehensive use of aquaculture, agriculture, and livestock with an emphasis on aquaculture) can be a good solution, which can contribute to food, income, and nutrition. Integrated fish farming is ecologically sound, where fish culture improves soil fertility by increasing the availability of nitrogen and phosphorus (Giap *et al.*, 2005; Dugan *et al.*, 2006) [14, 12]. Integrated fish farming generally offers a number of advantages over any monoculture of food production technologies. For instances, utilization of farm by-products and/or wastes for pond fertilization, while agricultural byproducts as fish feeds. Agriculture in association with aquaculture enhances overall returns of the farms (Berg, 2002; Pant *et al.*, 2005; Dey *et al.*, 2007; Kumaresan *et al.*, 2009) [8, 30, 11, 20], which in turn improve the social status and food consumption of the farmers (Ahmed and Garnett, 2010) [3].

Similarly, integrated agri-aquaculture system (IAAS) is linking aquaculture to conventional farming systems which can also be the alternative solution to the maximal resource utilization to improve the fish production. In particular, Integrated agri-aquaculture systems were initiated and developed to fulfill different basic requirements, for instances, the food security of subsistence family farms; or effective utilization of valuable resources (e.g. water) and control of pollution (Little and Edwards, 2003) [21]. For these occasions, integrated aquaculture and integrated agri-aquaculture systems are now widely practiced in different countries of the World (Zajdband, 2011) [37].

Similarly, integrated aquaculture is being practiced well in Mymensingh, Jessore and a few other districts of Bangladesh. Although integrated aquaculture is not well developed, the technology is being practiced at very few areas in Nilphamary district. Therefore, the study is focused on the initial understanding of the technological status of integrated aquaculture systems practiced in this area. The objectives also include identification of technical problems associated with integrated aquaculture and investigation of the socio-economic status of the integrated aquafarmers.

2. Materials and Methods

The study was carried out for a period of one year from July 2016 to June 2017 in two selected upazilas of Nilphamari district, namely Saidpur and Kishoreganj. A questionnaire was finalized after pre-test, and the primary data were collected from 76 farmers by face to face interview. Secondary data were collected from various sources viz., journal articles, published reports, Government officials (e.g. District and Upazila Fisheries Officers), NGO workers etc. The collected data were entered into Microsoft Excel spreadsheet and then analyses were carried out using SPSS, Version-20.

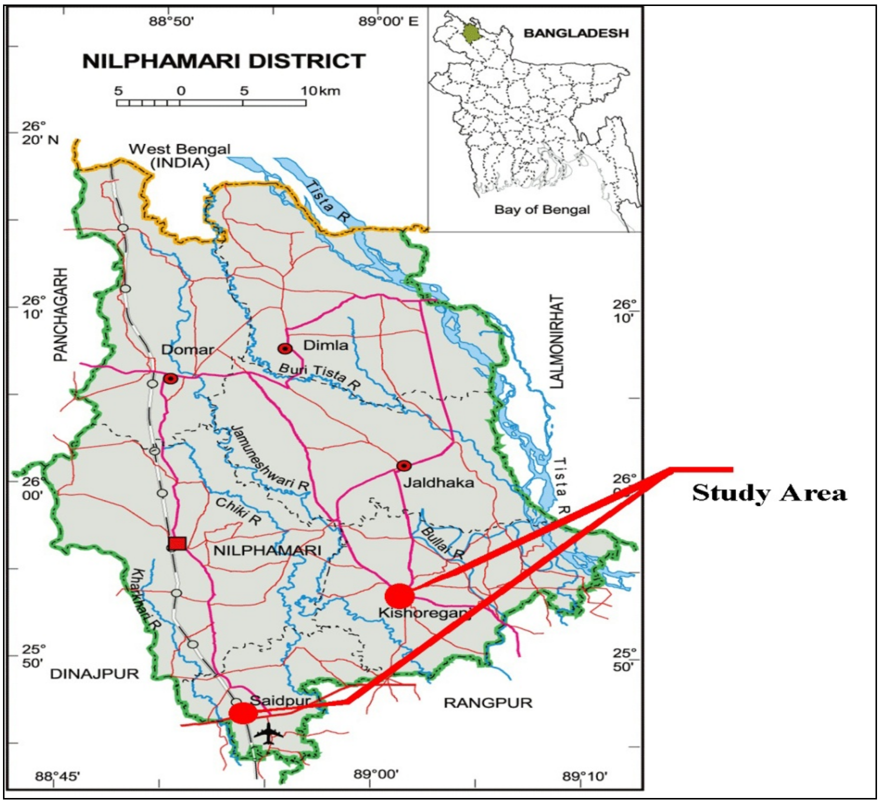

Fig 1: Map of Nilphamari district showing the study areas (Saidpur and Kishoreganj upazilas).

3. Results and Discussion

3.1 Socioeconomic Characteristics of Farmers

3.1.1 Family Size

The average family size was 4. On the basis of the number of family member, the respondents were categorized into two groups such as members from 2 to 4, and 5 to 8. The current study revealed that the family size of most of the farmers (62%) was 5-8 (Table 1). The data indicated that a few farmers' (20%) family size was higher than the national average size of 4.85 (BBS, 2016) [6]. Masud (2000) observed that average family size of farmers related to farming in inundated water bodies was 6, and 65% farmers lived in nuclear families [24].

3.1.2 Age Structure

Knowledge of the age structure of farm owners is important in estimating potential productive human resources. The age of the respondents was found to vary from 20 to 60 years that was classified into three categories: group 1 - between 20 and 40 years; Group 2 - between 41 and 60 years; and group 3 - above 60 years. The present study showed that majority of the farmers (71%) were between 41 to 60 years of age group (Table 1). Middle aged people are generally energetic and they are the most productive group to adopt new technologies and can take decision easily and promptly. Similar findings (70%) were reported by Rana (1996) [31]. Mitali (2005) reported that 53% farmers were in the age group of 31-40 years [26].

3.1.3 Annual Income

According to the study, nearly half (46%) of the farmers' annual income was BDT 1.51-1.8 lac. The majority of the farmers' main income source was integrated aquaculture. The average annual income found in the study area ranged from BDT 1.12 to 1.56 lac (Table 1). According to BBS (2016), the national average income was BDT 1.02 lac which is more or less similar to the findings of the present the study [6].

3.1.4 Education Levels

The respondents were classified into five categories. The education level of the most fish farmers was class eight pass (40%) followed by SSC (26%) and primary (22%) (Table 1). Very few farmers were of HSC and graduate levels. Educational status can play a vital role in efficient management and operation as well as in the successful production of fish.

Table 1: Socio-economic characteristics of integrated aquafarmers in the study areas

Parameters	Categories	No. of Respondents (%)
Family size	Small (2-4)	29 (38)
	Large (5-8)	47 (62)
Age structure (year)	Young (20-40)	06 (8)
	Middle age (41-60)	54 (71)
	Old (>60)	16 (21)
Annual income (lac)	1.2-1.5	16 (21)
	1.51-1.8	35 (46)
	1.81-2.00	08 (11)
	>2.00	17 (22)
Education levels	Primary	17 (22)
	Class eight	30 (40)
	SSC	20 (26)
	HSC	07 (9)
	Graduate	2 (3)

3.2 Fish Farming Information

3.2.1 Farm Size

In the study areas, the average farm size was 0.27 ha. Farm size of 25% farmers ranged from 0.13 to 0.20 ha, 58% farmers had 0.21-0.28 ha farm area and the rest 17% farmers' farm size was 0.29-0.36 ha. Islam and Dewan (1987) stated that size of land is an important variable for the production of fish [18]. On the basis of per unit area, land efficiency was greater in medium size plots (Mollah *et al.*, 1986) [27].

3.2.2 Farm Ownership

Ownership of plots also a vital factor to make decisions smoothly regarding fish farming. It was found that 64% farmers had their own land, 24% possessed farms of joint ownership and 12% farmers operated farming activities in leased lands (Table 2).

3.2.3 Experience of the Farmers

Experience of the farmers in integrated aquaculture was classified into three groups. The survey revealed that the respondents were relatively new in this profession. According to the study, experiences of the respondents were 1-4 years (21%), 5-9 years (32%), and 10-13 years (47%).

3.2.4 Training

Training experience and technical assistance play important roles in influencing aquaculture. Among the 76 interviewed fish farmers, 67% farmers received formal training on fish culture. They obtained training from different fisheries training and extension projects, Youth Development Center, Non-government organizations, Department of Fisheries (DoF), and Bangladesh Fisheries Research Institute (BFRI). The duration of the training ranged from 3 to 30 days. The data furnished that 50% farmers received training from DoF, 26% from different NGOs and 24% farmers were trained by BFRI. Training is very important for any profession including integrated aquaculture.

Table 2: Farming information of the selected integrated aqua-farmers

Parameters	Categories	No. of Respondents (%)
Farm size (ha)	0.13-0.20	19 (25)
	0.21-0.28	44 (58)
	0.29-0.36	13 (17)
Farm ownership	Self	49 (64)
	Joint	18 (24)
	Leased	9 (12)
Farmers experience (year)	1-4	16 (21)
	5-9	24 (32)
	10-13	36 (47)
Training status	Yes	51 (67)
	No	25 (33)
Training institution	DoF	38 (50)
	NGOs	20 (26)
	BFRI	18 (24)

3.3 Management Systems

3.3.1 Preparation of Plot and Ditch

Plot preparation includes dike reparation, removal of weeds, land ploughing for planting seedlings etc. On the other hand, ditch drying, eradication of weed fish, ditch construction etc. belonged to ditch preparation activities. Before releasing the fish fingerlings into the ponds, most of the farmers repaired dikes to protect the pond from over flooding. A few farmers (6%) were not aware of the importance of dike repairmen. Over 90% of the farmers repaired pond dykes before stocking fish seeds (Table 3). Pond preparation is a pre-requisite for successful fish culture. A suitable pond is required to minimize the production cost and maximize the production of fish. So, different questions were asked to the farmers regarding various aspects of pond preparation.

3.3.2 Application of Fertilizers

It was found that 96% farmers applied different organic and inorganic fertilizers in the integrated farming systems (Table 3). The commonly used fertilizers were urea, triple superphosphate (TSP), and cow dung, and the dosages were 200, 100, and 500 kg/ha, respectively. The purpose of using fertilizers is to grow natural foods for fish by improving the fertility of the soil, thereby increasing the yield of fish and land crops. The quantity of fertilizers is related to the farming systems practiced. Khan *et al.* (1997) recommended urea, TSP, muriate of potash (MP), and gypsum for rice-fish farming [19]. Mitali (2005) found that the average rates of fertilization were urea 120 kg/ha, TSP 66 kg/ha, and MP 48 kg/ha [26]. In the present study, the rates of fertilization were higher than that of the previous studies.

3.3.3 Feed, Feeding Rate, and Frequency

In the current study, it was found that 100% farmers provided feeds with the cultured fishes. Artificial feed (63%), farm-made feed (3%), and both artificial and home-made feed (34%) were supplied to the cultured species (Table 3). The most common commercial artificial feeds were Mega, Quality, Lili, Narish. CP, Aftab, and Aman feeds. The ingredients that were used for the preparation of home-made feeds were: rice bran, wheat bran, oil cakes etc. The ration size depends on the body weight of fish and the total area of a pond. According to the survey, 61% farmers applied feeds as per stocking density and the remaining 39% farmers supplied on the basis of body weight. Most of the farmers applied feed at 3-4% of fish body weight. It was found that 24% of the farmers supplied feed once a day (i.e. feeding frequency 1). Among them, 16% farmers applied feeds in the morning and 8% in the evening. On the other hand, 76% farmers supplied feed twice daily, in the morning and the evening. Supplementary feeds were applied by the most farmers in small-scale fish farming in rice fields, although it is an extensive aquaculture practice that primarily relies on the natural foods such as phytoplankton, zooplankton, periphyton, benthos etc. In integrated aquaculture systems, farmers mainly use on-farm inputs, such as rice bran, wheat bran and mustard oilcake (Ahmed and Garnett, 2011) [2]. Saha *et al*., (1995) reported that the farmers used rice bran and oil cakes in rice-fish farming [34].

3.3.4 Disease Treatment

It was found that 87% farmers were aware of prevention and control measures of diseases of cultured species and potentially adverse conditions in the farming systems. On the other hand, 13% farmers had no idea how to treat them (Table 3). The conscious farmers adopted preventive measures from the very beginning such as pond drying, liming, weed control, removal of undesirable species, water supply etc. to keep away the infectious pathogens and/or potential hosts of pathogen from the farms.

Table 3: Pond management systems observed in the study areas

Parameters	Categories	No. of Respondents (%)
Plot and ditch preparation	Yes	70 (92)
	No	06 (8)
Fertilizer Application	Yes	73 (96)
	No	03 (4)
Feed Types	Artificial	48 (63)
	Farm-made	02 (3)
	Both	26 (34)
Feeding Rate	Body weight basis	30 (39)
	Stocking density basis	46 (61)
Feeding Frequency	One (Morning or Evening)	18 (24)
	Two (Morning & Evening)	58 (76)
Disease Treatment	Yes	66 (87)
	No	10 (13)

3.4 Integrated Farming Systems

Three different types of integrated aquaculture systems were found in practice in the study areas: rice-fish culture (46%), fish-horticulture (33%), and fish-poultry (21%). Most of the farmers practiced rice-fish culture in the Aman rice fields, and a few others practiced during the Boro season due to the scarcity of water. Fish seeds were released into the ditches after 10-15 days of the rice plantation. Both concurrent and alternative systems were practiced by the farmers. The concurrent system was practiced during the Aman season in moderate or low paddy fields where water exists for about 4-5 months naturally. Rice was cultured from July to October and fingerlings were stocked in July-August and harvested in November. On the other hand, rice and fish were grown rotationally in the alternative system in deeply flooded low lands. Fingerlings were stocked in June-July after collection of rice and harvested in November-December, for a culture period of 5-7 months until rice plantation in the next season. Many alternate farmers cannot choose rice-fish integration in deep water rice fields due to water management problems. However, the culture of deepwater rice with fish during the flood season followed by dry season rice farming can be established in flood-prone rice field ecosystems (Dugan *et al.*, 2006) [12].

Fish-horticulture was the second popular integration system among the farmers. Some farmers practiced horticulture and poultry, horticulture and rice integration with the fish culture at the same time. Horticultural crops were planted in August-September in the top, inner and outer dikes of ponds as well as adjoining areas, and were harvested in December-January. Banana, papaya, lemon, brinjal, green leafy vegetables, chili etc. were the horticultural crops. Vegetables and fruit-bearing plants were also found in the dikes. Vegetables were grown twice a year - once during August-September and another in March-April. Pond preparation was done in March-April and fish seeds were stocked in May-June. Pond water was used for irrigation and bottom mud, a rich source of nutrients for plants, was used for field crops. Finally, fish was harvested in December-January.

Fish-poultry integration was not a popular practice. However, attention is growing in the farmer day by day. Chicken, raising for meat (broiler), was the sole species among the poultry crops integrated with fish in the study areas. The chicken was raised over and/or adjacent to the pond dikes. The chicken house was made of bamboo and other locally available cheap materials. The average stocking density of chicken was 1,235 birds/ha of pond area. A bird achieved an average marketable size of 1.5 to 1.7 kg within 6 weeks.

The study revealed that polyculture of fish in ponds was practiced by all the farmers (100%) as a strategy of cultivating many fish species together of different food habits and trophic levels. The fish species cultured in the study areas reported by the farmers were rohu (*Labeo rohita*), catla (*Catla catla*), mrigal (*Cirrhinus mrigala*), silver carp (*Hypophthalmichthys molitrix*), common carp (*Cyprinus carpio*), bighead carp (*Hypophthalmichthys nobilis*), sorputi (*Puntius sophore*) and tilapia (*Oreochromis niloticus*). Likewise, rohu, catla, mrigal, silver carp, bata, bighead carp, sorputi etc. were stocked for rice-fish farming. Das (1982) reported that different fish species, like mrigal, common carp and tilapia showed better growth performance in monoculture than in polyculture [10]. However, many farmers avoided common carp in rice fields as it uprooted and consumed the rice plants.

It was found that the farmers were not aware of maintaining any specific stocking ratio for different fish species. According to the study, the average stocking density was 11,115 fish/ha in ponds. Mitali (2005) observed that the average stocking density of fish in rice-fish culture was 14,659 fish/ha, which was a bit higher than that of the present study [26]. The stocking densities in simultaneous methods of rice-fish culture should be 2,500-3,000 and 5,000 fish/ha in monoculture and mixed culture, respectively (Ahmed *et al.*, 1995) [1].

Integrated fish farming produces more food than alternate farming such as horticulture or rice monoculture. Although productivity of an individual crop is lower in integrated farming systems (due to low levels of input) than it would be in a monoculture system, the overall farm output is higher.

The present study suggests higher yields can be achieved by increasing inputs. Intensification of fish culture in rice fields could also result in higher performance (Vromant *et al.*, 2002) [36]. However, the most suitable level of intensity is mainly determined by the availability of resources and management ability of the farmers. According to Shang and Tisdell (1997), higher production can be obtained by improving existing culture techniques and practices, removing bottlenecks or a combination of these alternatives [35].

There is a strong association between food production and consumption. As a result of integrated fish farming, the households of integrated farmers will be able to eat rice three times a day. Rice fields can potentially contribute considerable amounts of protein to fish farming households. Thus, the switch from rice monoculture to integrated fish farming is not merely a change in cropping system; it is also a shift to a more balanced diet (i.e., rice and fish). In addition to animal protein, small fish are a valuable source of micronutrients, vitamins, and minerals (Mohanty *et al.*, 2016) [28].

Several reports have suggested that rice monoculture and horticulture is not environmentally sustainable in the long-term and is eroding the natural resource base (Berg, 2001; Halwart and Gupta, 2004; Frei and Becker, 2005; Lu and Li, 2006) [7, 15, 13, 22]. Reduction in fertilizer and pesticide usage through the adoption of integrated pest management (IPM) is a long-term option to improve farm productivity in an environmentally friendly manner (Berg, 2002) [8]. Reduced application of fertilizers and pesticides in rice-based ecosystems conserve a great variety of aquatic flora and fauna (Halwart, 2008) [16]. According to Rothuis *et al.* (1998), the main benefits of integrated aquaculture are environmentally sustainable, system biodiversity, and decreased use of fertilizers and pesticides [33].

Increased application of fertilizers and pesticides in rice monoculture and horticulture has been releasing more radionuclides and residues leading to soil toxicity. Increased toxicity of the soil and water in rice fields has severely damaged the aquatic habitats along with the aquatic species in rice fields by 48-60% in Bangladesh (Ali *et al.*, 2004) [4]. Therefore, integrated aquaculture systems can provide sustainable alternatives to any other monoculture practices, and farmers can take advantages of the environmental benefits.

3.5 Problems and Constraints

Like other agro-business, integrated aquaculture also faces many different problems and constraints. The farmers in the study areas also encountered several problems which acted as barriers to integrated aquaculture. The main problem was low water retention capacity of the soil. Ponds cannot hold water throughout the year. Therefore, fish culture in the pond was possible for a period of maximum 7-8 months, which was not adequate for a good harvest of larger species like Indian major carps. Unavailability of quality fish seeds in sufficient quantity was also one of the major problems. Farmers collected seeds from a long distance or from the fry traders. Other important constraints and problems in integrated aquafarming reported by the farmers were high price of inputs and low price of outputs, lack of capital, inadequate scientific and technical knowledge on the combination of different components of integrated farming systems, insufficient extension services, high lease value, poor loan facility, poor growth of fish, low levels of water during the summer, poaching, poor water quality, high labor cost, insufficient transportation facilities, bad roads, and diseases, pests and predators of the cultured organisms. Similar findings were reported by Marina (2009) [23] and Robbani (2002) [32].

4. Conclusion

Integrated aquaculture practices in the study areas are still at the preliminary stage. Most of the farmers practice tradition culture systems due to lack of modern technological knowledge and lack of capital. The proper utilization of the unused lands and ponds in an integrated way can contribute to the improvement in the farm yield and socio-economic conditions of the farmers. It is also essential to spread the modern technological knowledge and provide more training facilities with the integrated fish farmers, which will increase the management efficiency of the farmers as well as the overall farm outputs. Therefore, the Government, NGOs, and concern stakeholders should take necessary steps for the improvement the sector, which in turn will contribute to the development of the national economy.

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