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Status of existing integrated aquaculture system of some areas in Sadar upazila of Dinajpur district, Bangladesh

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Abstract

This study was conducted to know the current status of integrated aquaculture system in Dinajpur Sadar Upazila, Bangladesh. For this purpose, randomly selected 100 integrated aquaculture farmers were interviewed through a pre-tested well-structured questionnaire from February 2019 to August 2019. Average cost and income of rice-fish culture (34 farmers) were 2.08 ± 1.96 and 6.61 ± 6.23 for fish; 0.28 ± 0.26 and 1.22 ± 1.15 for rice, in vegetable-fish culture (47 farmers) 7.05 ± 1.76 and 22.35 ± 5.59 for fish; 0.41 ± 0.06 and 1.59 ± 0.26 for vegetable, in fruit-fish culture (4 farmers) 1.07 ± 0.12 and 3.43 ± 0.4 for fish; 0.52 ± 0.12 and 1.44 ± 0.33 for fruit, in poultry-fish culture (10 farmers) 5.18 ± 4.8 and 16.43 ± 15.21 for fish; 3.09 ± 2.61 and 3.62 ± 3.07 for poultry and in duck-fish culture (5 farmers) 1.19 ± 0.57 and 3.89 ± 1.87 for fish; 0.39 ± 0.2 and 0.96 ± 0.49 for duck, respectively. Among them fruit cum fish culture showed significant ($P<0.05$) value of fish production. Maximum fish production (11.11 ton/ha) and highest combine net profit (10.30 lac Tk/ha) were found in duck-fish culture. As a secondary crop, poultry showed highest net profit (21.4 lac Tk/ha) during the research. It can be concluded that farmers get benefited from integrated aquaculture using minimum amount of cost and can improve their economic conditions.

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Introduction

Bangladesh is one of the world's leading fish producing countries ranked 3*rd* in inland open water capture production and 5*th* in world aquaculture production (FAO, 2018). In 2017-2018 fiscal years, total fish production was 42.77 lakh MT, while aquaculture production contributed 56.24% of the total fish production (DoF, 2018). Integration of aquaculture has great potentialities in agricultural economy and can help to increase the employment opportunities throughout the year (Jayanthi *et al.*, 2000; Singh *et al.*, 1993 and Singh *et al.*, 1997).

Integrated Agriculture-Aquaculture (IAA) is mostly adequate for the resource less peoples for obtaining highest advantages from land, water, and labor (Nhan *et al.,* 2007; Ahmed *et al.,* 2012). It covers mainly the integration of fish, livestock, vegetables, fruits, and rice (FAO, 2001; Halwart and Gupta, 2004; Prein, 2002; Jamu and Piedrahita, 2002). Wastes from one process in IAA are recycled as inputs to another, and thus, pollution is diminished (Jamu and Piedrahita, 2002). Integrated livestock-fish culture includes poultry-fish integrated farming, cattle-fish integrated farming, and duck-fish polyculture system. In Bangladesh, ice-fish and duck polyculture system had been practiced in Khulna district (Ogello *et al.*, 2013). Ducks played a role as manure helped to form natural feed and also helped for rice culture. This better performance with rice and duck may due to enhanced plankton production from duck's manure and spilled duck feed which was allowed to fall directly to the fishpond. Ali, *et al.,* (1997) observed that duck excreted organic carbon, phosphorus, nitrogen, potassium and calcium significantly contributed to fish production and nutrient continent of duck excreta also influenced on fish production.

Dinajpur Sadar Upazila, is located at 25.6333° N and 88.6500° E; bounded by two upazilas on the north, Kaharole and Khansama, West Bengal state of India on the south, Chiribandar upazila on the east and Biral upazila on the west. It covers an area of about 354.34 sq km (Wikipedia, 2019). It is rich in agricultural, dairy and fisheries resources. Farmers are involved in integrated culture system to minimize wastes from various agricultural enterprises. Integration aquaculture has paid considerable attention in recent years through poverty reduction in society, employment opportunity as well as women participation in family income and lightening malnutrition. Integrated farming is particularly beneficial for the rural poor (Vincke, 1991). Based on this point few works have been done on the integrated aquaculture system practiced in this area so far. Though the agricultural production with nutrient management is an environmental issue but in this study surplus production of crop, utilization of maximum resources and especially poverty reduction were considered by an integrated aquaculture practice. Therefore, the research was designed to evaluate the present status of integrated aquaculture system of Sadar upazila in Dinajpur district.

Materials and methods

Study area and period

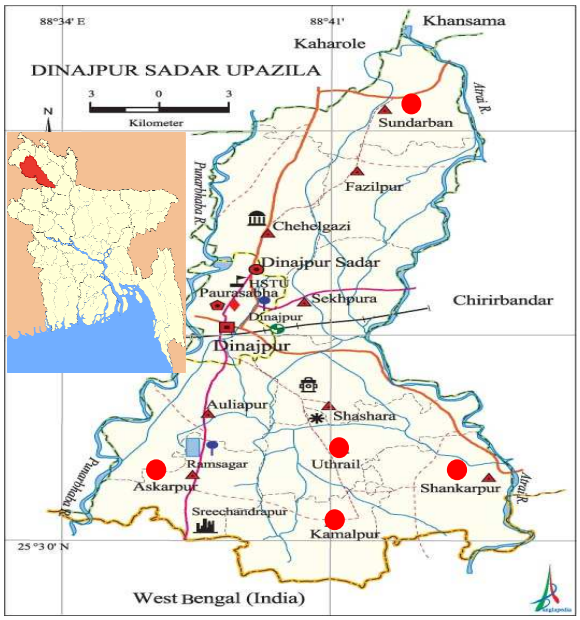

Fig. 1. Showing the study area practiced integrated aquaculture in Dinajpur Sadar upazila (Source: Banglapedia, 2015).

Dinajpur Sadar Upazila consists of ten unions namely, Auliapur, Askarpur, Uthrail, Kamalpur, Chehelgazi, Fazilpur, Shankarpur, Shashara, Sekhpura and Sundarban. Among them integrated aquaculture systems were practiced in five unions namely, Uthrail, Shankarpur, Askarpur, Sundarban, and Kamalpur (Fig. 1). Data were collected from February 2019 to August 2019.

Data Collection

Union visits and questionnaire based interview methods were used for data collection from both primary and secondary sources.

Face to face interview was followed during data collection from integrated culture. Focus group discussion and sometimes crosscheck interview were done to obtain more reliable data. Upazila fisheries office, livestock office, agriculture office, various books, reports, journals and thesis papers were also used as secondary source for data collection.

Data Processing and analysis

Collected data were accumulated, summarized, arranged and analyzed in Microsoft excel and Microsoft word, respectively.

Statistical analysis of data namely, independent sample t-test and one-way ANOVA (Analysis of Variance) was performed for assessing any significant difference between or among the parameters using SPSS (Statistical Package for Social Science) version 22.0 at a 5% level of significance.

Results

Rice-Fish Culture

Farmers were involved in rice production with fish culture to get extra income from fish culture. Mainly *Cyprinus carpio* var. *communis* (Common carp), *Cyprinus carpio* var. *specularis* (Mirror carp) *Hypophthalmicthys molitrix* (Silver carp), and *Aristichthys nobilis* (Bighead carp), and *boro* rice varieties BRI- Rice-28, BRI-Rice-29 and BRI-Hybrid-1 were cultured in the rice cum fish culture system. Farmers used Mega feed (Spectra Hexa Feeds Ltd.) as fish feed for proper growing of fish depends on fish age and stocking density. In case of small size fish (fingerling fish) 0.19 kg Mega feed were used per decimal (40 m^2) area. Fertilizers such as Urea and TSP (0.625 kg per decimal) and cow dung (2.08 kg per decimal) were applied. The total cost of pond fish culture was 2.08 ± 1.96 (Mean ± SD) lac (1 lac= 0.1 million) BDT (Bangladeshi taka) and total cost for rice was 0.28 ± 0.26 lac BDT for *boro* season (6 months). The total net income of rice-fish culture was 4.52 ± 4.26 lac BDT for fish (9.57 lac BDT/ha) and 0.94 ± 0.88 lac BDT was for rice (0.90 lac BDT/ha). No significant difference ($P<0.05$) of total net income was found among farmers of different unions in rice cum fish culture system (Table 1).

Table 1. Production, total cost, income and net profit (mean ± SD) of Rice-fish culture (per hector).

Union	Total farmer	Fish production (ton) and cost (lac BDT)									Rice production (ton) and cost (lac BDT)							
		Area (ha)	Stocking cost	Feeding cost	Others cost	Total cost	Production	Income	Total net profit	*P*- value	Area (ha)	Fertilizer cost	Other cost	Total cost	Production	Income	Total net profit	*P*- value
Sundrban	20	1.14	0.59	3.27	1.17	5.03	12.27	15.94	10.91		2.52	0.45	0.23	0.68	15.6	2.94	2.26	
Uthrail	5	0.25	0.13	0.73	0.26	1.12	2.75	3.56	2.44		0.57	0.1	0.05	0.15	3.55	0.66	0.51	
Shankarpur	5	0.22	0.11	0.63	0.22	0.96	2.35	3.05	2.09		0.45	0.08	0.04	0.12	2.8	0.52	0.4	
Komolpur	4	0.28	0.14	0.79	0.28	1.21	2.97	3.85	2.64		0.62	0.11	0.05	0.16	3.82	0.71	0.55	
Total	34	1.89	0.97	5.42	1.94	8.32	20.34	26.44	18.08	0.06	4.16	0.74	0.37	1.11	25.7	4.86	3.75	0.69
Mean ± SD						2.08± 1.96	5.08± 4.79	6.61± 6.23	4.52 ± 4.26		Mean ± SD			0.28± 0.26	6.43± 6.09	1.22± 1.15	0.93± 0.88	
Per hector						4.40	10.76	13.99	9.57		Per hector			0.27	6.18	1.17	0.90	

BDT= Bangladeshi taka (80 BDT = 1US$)

P- Value <0.05 = significant

Vegetable-fish culture

Most farmers ascertained the technology of pond dyke systems through regular addition of pond mud for culturing vegetables such as Asparagus bean *(Vigna unguiculata)* locally name as "Borboti", and Bean *(Lablab purpureus)* locally name as "sheem".

Fish species such as silver carp (*Hypophthalmicthys molitrix*), Mirror carp (*Cyprinus carpio* var. *specularis*), Bata (*Labeo bata*), Rui (*Labeo rohita*), Catla (*Gibelion catla*), Grass carp (*Ctenopharyngodon idella*), Sarputi (*Puntius sarana*) and Bighead carp (*Aristichthys nobilis*) were cultured in pond. Farmers applied Mustard oil cake (MOC) and Rice bran with fish feed during fish culture. Total net income was 15.3 ± 3.83 lac BDT for fish (9.59 lac BDT /ha) and 1.19 ± 0.2 lac BDT for vegetable (4.03 lac BDT /ha) for six months. In vegetable cum fish culture, no significant difference ($P<0.05$) of total net income was found among farmers of different unions (Table 2).

Table 2. Production, total cost, income and net profit (mean ± SD) of Vegetable-fish culture (per hector).

Union	Total farmer	Fish production (ton) and cost (lac BDT)									Vegetable production (ton) and cost (lac BDT)							
		Area (ha)	Stocking cost	Feed+Labor cost	Other cost+ Fertilizer	Total cost	Production	Income	Total net profit	*P*- value	Area(ha)	Labor+ Entresol cost	Other cost	Total cost	Production	Income	Total Net Profit	*P*- value
Uthrail	9	1.12	0.57	3.19	1.15	4.91	11.96	15.55	10.64		0.25	0.3	0.06	0.36	2.29	1.37	1.01	
Shankarpur	8	1.37	0.7	3.9	1.4	6	14.62	19.01	13.01		0.26	0.3	0.07	0.37	2.37	1.42	1.05	
Askorpur	8	1.5	0.77	4.31	1.54	6.62	16.15	21	14.38		0.27	0.31	0.07	0.38	2.48	1.48	1.1	
Komolpur	12	2.02	1.04	5.83	2.08	8.95	21.83	28.38	19.43		0.38	0.42	0.09	0.51	3.39	2.03	1.52	
Sundarban	10	1.98	1.01	5.71	2.05	8.77	21.39	27.81	19.04	0.056	0.31	0.34	0.08	0.42	2.77	1.66	1.24	0.06
Total	47	7.98	4.09	22.94	8.22	35.25	85.95	111.8	76.5		1.47	1.67	0.37	2.04	13.3	7.96	5.92	
Mean± SD						7.05 ± 1.76	17.19 ± 4.3	22.35 ± 5.59	15.29 ± 3.83		Mean ± SD			0.41 ± 0.06	2.66 ± 0.44	1.59 ± 0.26	1.18 ± 0.2	
Per hector						4.42	10.77	14.00	9.59		Per hector			1.39	9.05	5.41	4.03	

BDT= Bangladeshi taka (80 BDT = 1US$)

P- Value <0.05 = significant.

Fruit-fish culture

Farmer practiced fruit garden in pond dyke and a remarkable scenario was noticed in Shankarpur and Askorpur union. Fruit such as "Banana" (locally called "Malvog") culture in the pond dyke was the different aspect of culture in which farmer got extra income. In fruit cum fish culture, total cost of fish and fruit was 1.07 ± 0.12 and 0.52 ± 0.1 lac BDT, respectively. Total production of fish and fruit was 2.61 ± 0.3 and 1.15 ± 0.2 lac BDT, respectively for six months and total net income of fish and fruit were 2.4 ± 0.28 lac BDT (9.81 lac BDT/ha) and 0.92 ± 0.22 lac BDT (7.67 lac BDT/ha). No significant difference ($P>0.05$) of total net income was observed in fish production but there was a significant difference ($P<0.05$) of total net income in fruit production between farmers of two unions in fruit cum fish culture system (Table 3).

Poultry-fish Culture

The poultry house was raised over the pond (vertical integration) to minimize transport and maximizing land usage. Poultry broilers were integrated with fish farming to reduce the cost of inputs such as fertilizer and feed to maximize profits. Total cost of poultry culture was 3.09 ± 2.61 lac BDT where total production of poultry was 12.64 ± 11.7 ton and total income was 3.62 ± 3.07 lac BDT for six months. On the other hand, total cost of fish culture was 5.18 ± 4.8 lac BDT where total production of fish was 12.6 ± 11.7 ton and total income was 16.43 ± 15.21 lac BDT. Total net income from fish production was 9.61 lac BDT/ha and 21.4 lac BDT/ha from poultry production by completing four production cycles within six months. Maximum net profit (21.4 lac BDT/ha) was found in poultry production among the secondary

crops (except rice-fish culture) (Fig. 2). There was no significant difference ($P<0.05$) of total net income in both fish and poultry production between farmers of two unions in this culture system (Table 4).

Table 3. Production, total cost, income and net profit (mean ± SD) of Fruit-fish culture (per hector).

Union	Total farmer	Fish production (ton) and cost (lac BDT)									Fruit production (ton) and cost (lac BDT)							
		Pond Area (ha)	Stocking cost	Feeding cost	Other cost	Total cost	Production	Income	Total net profit	*P*- value	Fruit Area (ha)	Fertilizer cost	Other cost	Total cost	Production	Income	Total Net Profit	*P*- value
Shankarpur	2	0.22	0.11	0.64	0.23	0.98	2.40	3.14	2.16		0.10	0.26	0.17	0.43	0.96	1.20	0.77	
Askorpur	2	0.26	0.13	0.76	0.27	1.16	2.83	3.71	2.55		0.14	0.36	0.25	0.61	1.34	1.68	1.07	
Total	4	0.48	0.24	1.40	0.50	2.14	5.23	6.85	4.71	0.29	0.24	0.62	0.42	1.04	2.30	2.88	1.84	0.01
Mean ± SD						1.07± 0.12	2.61 ± 0.3	3.43 ± 0.4	2.35± 0.28		Mean ± SD			0.52± 0.12	1.15± 0.27	1.44± 0.33	0.92± 0.21	
Per hector						4.46	10.90	14.27	9.81		Per hector			4.33	9.58	12.00	7.67	

BDT= Bangladeshi taka (80 BDT = 1US$)

P- Value <0.05 = significant

Table 4. Production, total cost, income and net profit (mean ± SD) of Poultry-fish culture (per hector).

Union	Total farmer	Fish production (ton) and cost (lac BDT)									Poultry production (ton) and cost (lac BDT)								
		Pond Area (ha)	Stocking cost	Feeding cost	Other cost	Total cost	Production	Income	Total Net Profit	*P*- value	Poultry Area (ha)	Seed cost	Feed cost	Other cost	Total cost	Production	Income	Total net Profit	*P*- value
Sundarban	8	1.94	1.00	5.59	1.99	8.58	20.91	27.18	18.60		0.04	1.96	1.91	1.07	4.94	7.25	5.8	0.86	
Komolpur	2	0.40	0.20	1.17	0.42	1.79	4.36	5.67	3.88		0.01	0.49	0.48	0.27	1.24	1.81	1.45	0.21	
Total	10	2.34	1.20	6.76	2.41	10.37	25.27	32.85	22.48	0.43	0.05	2.45	2.39	1.34	6.18	9.06	7.25	1.07	0.35
Mean± SD						5.18± 4.8	12.64± 11.7	16.43± 15.21	11.24± 10.4		Mean ± SD				3.09± 2.61	4.53± 3.84	3.62± 3.07	0.54± 0.45	
Per hector						4.43	10.80	14.04	9.61		Per hector				123.6	181.2	145	21.4	

BDT= Bangladeshi taka (80 BDT = 1US$)

P- Value <0.05 = significant

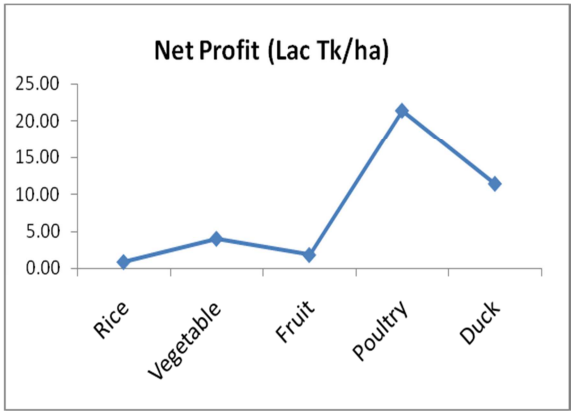

Fig. 2. Comparative study of total net profit among various integrated crops practiced with aquaculture in Dinajpur Sadar upazila from February 2019 to August 2019.

Duck-fish Culture

In this integrated system, ponds provided living and foraging areas for the ducks and fish. The combination of duck and fish farming was considered as a means of reducing the cost of feed for ducks and an inexpensive way of fertilizing fish ponds. Hence, the rationale for integrated duck-fish culture stronger than many other animal-fish systems. Total cost of fish culture was 1.19 ± 0.57 BDT where total production of fish was 2.96 ± 1.42 ton and total income from fish production was 3.89 ± 1.87 BDT. On the other hand, total cost of duck was 0.3 ± 0.2 BDT where total production of duck

was 0.48 ± 0.24 ton and total income from duck production was 0.96 ± 0.48 BDT. Total net income from fish production was 2.69 ± 1.29 BDT (10.1 lac BDT/ha) and 0.56 ± 0.28 BDT from duck culture (11.43 lac BDT/ha) in this culture system. No significant difference of total net income from both fish and duck production ($P<0.05$) was observed in this culture system (Table 5). The highest net profit (10.30 lac BDT/ha) and the maximum fish production (11.11 ton/ha) was noticed in duck cum fish culture compared to other integrated culture systems during this study (Fig. 3 and 4).

Table 5. Production, total cost, income and net profit (mean ± SD) of Duck-fish culture.

Region (Union)	Total farmer	Fish production (ton) and cost (lac BDT)									Duck production (ton) and cost (lac BDT)								
		Pond (ha)	Stocking cost (Tk)	Feeding cost	Other cost	Total cost	Production	Income	Total Net Profit	*P*- value	Duck (ha)	seed cost	Feeding cost	Other cost	Total cost	Production	Income	Total Net Profit	*P*- value
Uthrail	1	0.12	0.06	0.35	0.13	0.54	1.35	1.78	1.24		0.024	0.09	0.08	0.03	0.2	0.24	0.48	0.28	
Sundarban	2	0.36	0.18	1.06	0.38	1.62	4.05	5.34	3.72		0.073	0.27	0.24	0.09	0.6	0.72	1.44	0.84	
Komolpur	2	0.32	0.16	0.93	0.34	1.43	3.49	4.55	3.12	0.36	0.05	0.18	0.16	0.06	0.39	0.48	0.96	0.56	0.35
Total	5	0.80	0.40	2.34	0.85	3.59	8.89	11.67	8.08		0.147	0.54	0.48	0.18	1.19	1.44	2.88	1.68	
Mean ± SD						1.19± 0.57	2.96± 1.42	3.89± 1.87	2.69± 1.29		Mean± SD				0.39± 0.2	0.48± 0.24	0.96± 0.48	0.56± 0.28	
Per hector						4.49	11.11	14.59	10.10		Per hector				8.10	9.80	19.59	11.43	

BDT= Bangladeshi taka (80 BDT = 1US$), *P*- Value <0.05 = significant

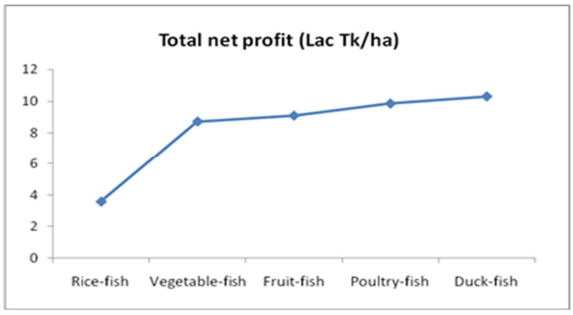

Fig. 3. Comparison of total net profits (Lac Tk/ha) among the five integrated crops found in Dinajpur Sadar upazila from February 2019 to August 2019.

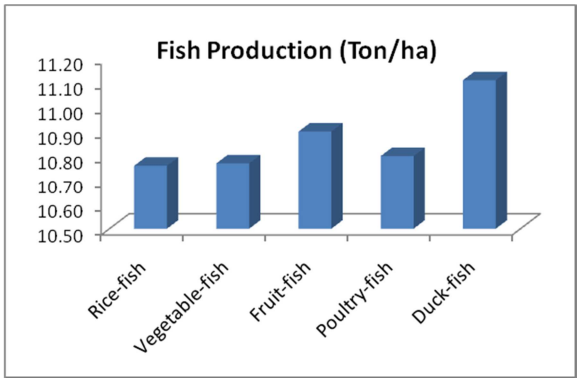

Fig. 4. Comparison of fish production (ton/ha) among different integrated systems in Dinajpur Sadar upazila from February 2019 to August 2019.

Discussion

Integrated aquaculture has great potential in Bangladesh by providing food, nutrition and poverty alleviation both directly and indirectly. Poor people get benefit by improving their livelihoods through employment opportunity (Yap, 1999; Halwart *et al.,* 2005). In inland area, aquaculture can be integrated with agricultural crops by using pond water, pond dikes and connected rice-fields (Edwards, 1999; Halwart, 2005; Little and Edwards, 1999; Little and Edwards, 2003; Edwards, 2000; Edwards *et al.,* 2002). In this research, total cost for rice cum fish culture was 1.56 lac BDT/ ha, total income was 5.17 lac BDT/ ha and total net income was 3.61 lac BDT/ ha. It was noticed that total income increased compared to total cost in rice-fish farm, which was similar to the findings of Cruz *et al.* (2009). They reported that total cost was 0.66 lac BDT/ ha, total returns was 1.5665 lac BDT/ha and net returns was 0.906 lac BDT/ha from rice-fish farm. In another study, Marco Barzman and Luther Das (2000) mentioned that rice yields were not inferior to those of farmers practicing rice-only. Fish was used as a secondary crop in this

integrated system and fish production was found lower comparatively where it was a primary one.

During the study, total cost, total income and total net income were 3.95 lac BDT/ha , 12.68 lac BDT/ha and 10.47 lac BDT/ha, respectively in vegetable cum fish culture. In fruit-fish culture, total cost total income and total net income were 4.42 lac BDT/ha, 13.51 lac BDT/haand17.48 lac BDT/ha, respectively. Tripathi and Sharma (2009)[b] found that total operational costs was 0.15 lac BDT/ha, total income was 0.61 lac BDT/ha, and total net balance was 0.46 lac BDT/ha in fish-vegetable culture. Shamsuddoha and Janssen (2003) claimed that vegetable production with fish culture was more attractive to poorer people because of more production and better economic benefits than fish culture alone. The outcomes from vegetable cum fish culture and fruit cum fish culture were more or less identical with the findings of the above authors. It was observed that leaves provided by vegetables used as feed for grass carp and sarputi in the vegetable cum fish culture systems where Shamsuddoha and Janssen (2003) found for grass carp only.

In poultry cum fish culture, total cost of poultry-fish culture was 6.92 lac BDT/ha, Total income was 16.78 lac BDT/ha, and Total net income was 9.86 lac BDT/ha. Gupta and Noble (2009) noticed that poultry-fish culture of total cost was 1.75 lac BDT/ha, total income was 4.1 lac BDT/ha, and then rest balance 2.35 lac BDT/ha. They noticed that higher income was obtained by using the minimum amount of cost, which was similar to this research. During the six months birds completed four production cycles and the production was more or less same in all cycles but it was difficult to maintain the birds in winter. During this time, the maximum birds suffered in various diseases and the production hampered. Furthermore, poultry production possessed comparatively high net income than other crops related with aquaculture because of their more production cycles in a short time period.

In case of duck cum fish culture, total cost of Duck-fish culture was 5.05 lac BDT/ha, Total income was 15.36 lac BDT/ha and then rest balance was 10.31 lac BDT/ha. Tripathi and Sharma (2009)[a] found that a total cost was 0.49 lac BDT/ha, total income was 1.48 lac BDT/ha, and then rest balance 0.99 lac BDT/ha. It was observed that better net profit was gained by providing a good investment in the integrated system. Similar results were found by Nuruzzaman (1991), Jhingran and Sharma (1980) and Uddin (1990). They observed that, yield was 5-7 times higher than normal fish production in duck-fish farming. A detail of input costs and return for a years' production of fish-duck farming system showed that the net profit was 1.92 lac BDT/ha (Nuruzzaman, 1991). In another study, Huque and Ebadul (1991) observed an average fish yield 3.22tons/ha in a period of 4 months culture of fish raising at Bangladesh Livestock Research Institute with three types of duck breeds for selecting duck breed for the integrated system. In the present study, fish production was 11.11tons/ha in the fish-duck farming system. This information differs from the previous one. It might be due to difference in culture period, culture system, and culture purposes and so on. In the study area, maximum culture was done on commercial basis.

In this study, the fruit cum fish culture system fruit production was 9.58tons/ha showed significant ($P<0.05$) production than other integrated systems. The less number of farmers and the less variation in the income of selling the product may be the causes. It was observed that fruit production contributed to a great extent in the reduction of malnutrition with a significant income in the rural areas. It was also noticed that the pond dike served a better fruit production because of nutrient rich pond water and its dike which was similar to the statement given by Yadav *et al.* (2013). However, huge population pressure in animal protein as well as nutrition deficiency may be overcome by the proper utilization of all resources and sustainable agricultural production, which can be achieved by the integrated aquaculture systems.

Conclusion

Integrated aquaculture may be a good option as income generating source in the northern area of Bangladesh. It can be obtained twin or more production by giving same effort which can be more

profitable than single one with maintaining the sustainable production of each crop by using all resources including land and water. In the rural areas, peoples are ready to provide extra effort and time for the extra income, but fund as well as loan facilities are the main obstacle for their development works. To meet up the nutritional demand and reduce poverty from the society, government and non- government organizations should take the initiatives to provide enough funds to the small scale farmers for the integrated farming in the country.

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