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Research Article

Environmental evaluation of different shrimp farming systems of Bangladesh: A Life Cycle Assessment approach

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ABSTRACT

Within the overall agro-based economy of the country, the contribution of shrimp production has been considered to grip excellent promise for creating jobs, earning overseas money and supplying protein. However, a number of issues including environmental aspects of marine shrimp farming in Bangladesh are being important day by day for sustainable trade, as consumers of importing countries are demanding environmentally friendly product. Life cycle assessment (LCA) has been promoted as a good tool for evaluating seafood products. This study was aimed to evaluate overall resource use and environmental impact caused by six shrimp farming systems and to identify hotspots and improvement options. The inventory covered the entire chain from shrimp brood collection to shrimp harvesting at farm, mentioned as "cradle to farm gate". Three functional units based on area (one hectare), weight (one tonne) and calorie content (one KCal) were adopted. Allocation by economic value was applied to allocate environmental burdens in case of multiple outputs. To assess the environmental impact, the last update of the CML impact assessment method was used. Selected impact categories included global warming, acidification and eutrophication. Life cycle inventory (LCI) and life cycle impact assessment (LCIA) results were calculated using CMLCA software (Version 5.2). Based on total score of the studied impact categories Extensive (Shrimp + Fish) had the lowest impact for per ha, KCal and ton shrimp production, whereas Semi intensive (Shrimp) was responsible for highest impact for per hectare shrimp production; Improved extensive (Shrimp + Prawn + Fish), was for per KCal production; and Better Management Practice (Shrimp + Fish) and Modified Traditional Technology (Shrimp + Fish) were for higher impact for per ton of shrimp production. Among different farming stages (viz. fertilization, stocking, feeding and power supply), feeding and fertilization were identified the major contributors for the environmental impacts associated with the different shrimp farming systems. Emphasize on natural feed based shrimp farming along with balanced supplementary feed prepared by environmental friendly ingredients was the major recommendation to increase production addressing both economic and environmental sustainability.

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1. INTRODUCTION

Fish and fisheries products comprise the second largest export earning sector in Bangladesh, with a contribution of 2.01% to the total export earnings and 3.69% to gross domestic product (GDP) in 2013-2014 (DoF 2015). In the same fiscal year, frozen shrimps contributed 86% of total export earnings from fisheries products (DoF 2015). Within the overall agro-based economy of the country, the contribution of shrimp production has been considered to grip excellent promise for creating jobs, earning overseas money and supplying protein. With recognition of huge dependence on natural ecosystems, the growth of export-oriented shrimp farming has been facing challenges in terms of the capacity of the environment to accommodate the increased levels of intensification of farming practices. The issues of efficiency of resource utilization and environmental degradation as a result of shrimp farming have raised serious doubts whether the sector can be operated in a sustainable way.

The trade-off between policy and practice and its reflection on sustainability has become a continuous tension. Focus has shifted from sustainable production to sustainable consumption. The new market demand necessarily requires Bangladesh to familiarize its industry activities to satisfy the international trade conditions and survive the global competition. In future the shrimp sector of Bangladesh may face great problem to export and many of the processing plants as well as earning of foreign currency may become closed and a lot of people involving this sector may become unemployed, if certification of eco-labeling in this sector is uninsured. In order to minimize this conflict and mitigate the tension between producers, market intermediaries and consumers, it is necessary to assess the systems overview and sustainability issues including environmental, social and economic aspects at all stages of life cycle of shrimp aquaculture product in Bangladesh. A good tool to evaluate the challenges of environmental issues is life cycle assessment (LCA), by which better practices can be identified and future eco-labeling certification may be ensured (Pelletier and Tyedmers 2008).

2. MATERIALS AND METHODS

This study has been structured in accordance to all four phases of LCA, as described by ISO (ISO 2006a; ISO 2006b), shown in Figure 1, including goal and scope, life cycle inventory (LCI) analysis, life cycle impact assessment (LCIA) and interpretation.

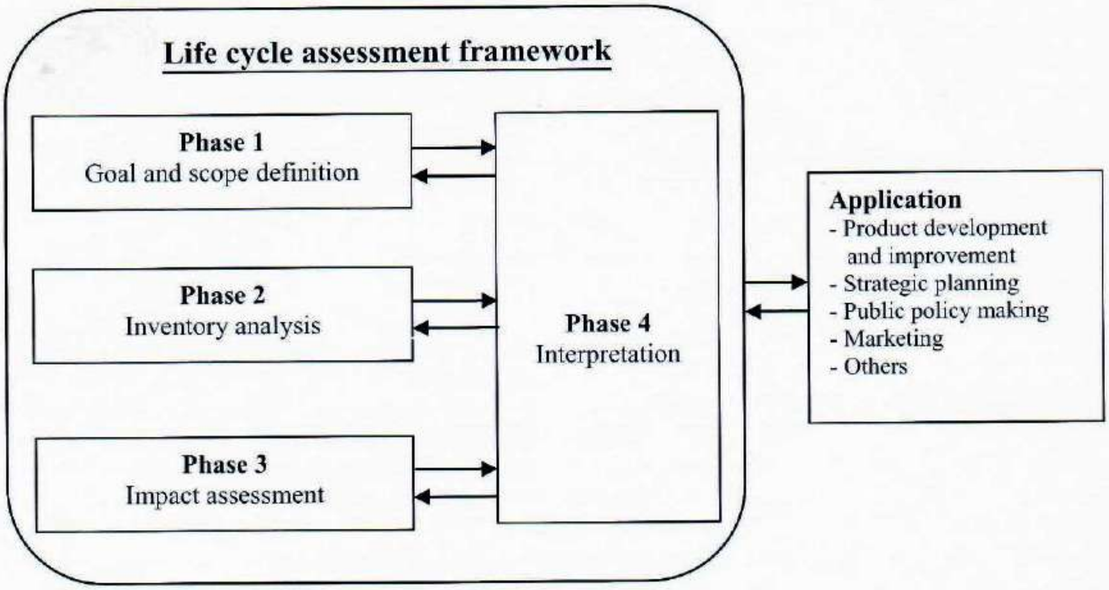

Figure 1: General framework and phases of LCA from ISO 14044

The study was conducted as part of FAO (Food and Agricultural Organization) Blue Growth Initiative (BGI) project as a step towards evaluating the environmental performance of Bangladeshi aquaculture product using a life cycle perspective. By identifying the key stages and the environmental impacts in the life cycle of the shrimp production system, LCA can facilitate identification of management strategies based on specific measures to improve the environmental performance of the whole production chain. The information obtained through the LCA study will be used to support development of national plans and policies for a more sustainable shrimp aquaculture.

Commercial aquaculture mostly and/or essentially depends on various inputs like seed, feed, fertilizers, transportations etc. To assess the environmental performance of commercially produced sea food, it is essential to know the environmental information of the ingredients used to produce sea food. The product system to be studied here is integrated freshwater shrimp farming in Bangladesh.

The environmental comparison among different shrimp farming systems and relative contribution of different produces of these systems here were therefore established on the basis of area (one hectare), weight (one ton) and calorie content (one KCal).

The system boundaries here were analysed from "cradle to farm-gate", which started from shrimp broodstock collection and ended at farm-gate before selling the produces. Flowchart of commonly used shrimp feed resources, including the system boundary, is illustrated in Figure 2. Foreground system (the system of direct interest) included broodstock collection, PL production in hatchery, cultivation and processing of different feed ingredients etc. The background system was comprised of lifecycles having materials and energy imported into the foreground system as well as distribution (transportation at different stages) and use of fertilizer, lime, diesel, electricity, etc. Consequences of land-use and land-use change (LULUC), and construction of buildings, were, however, not considered.

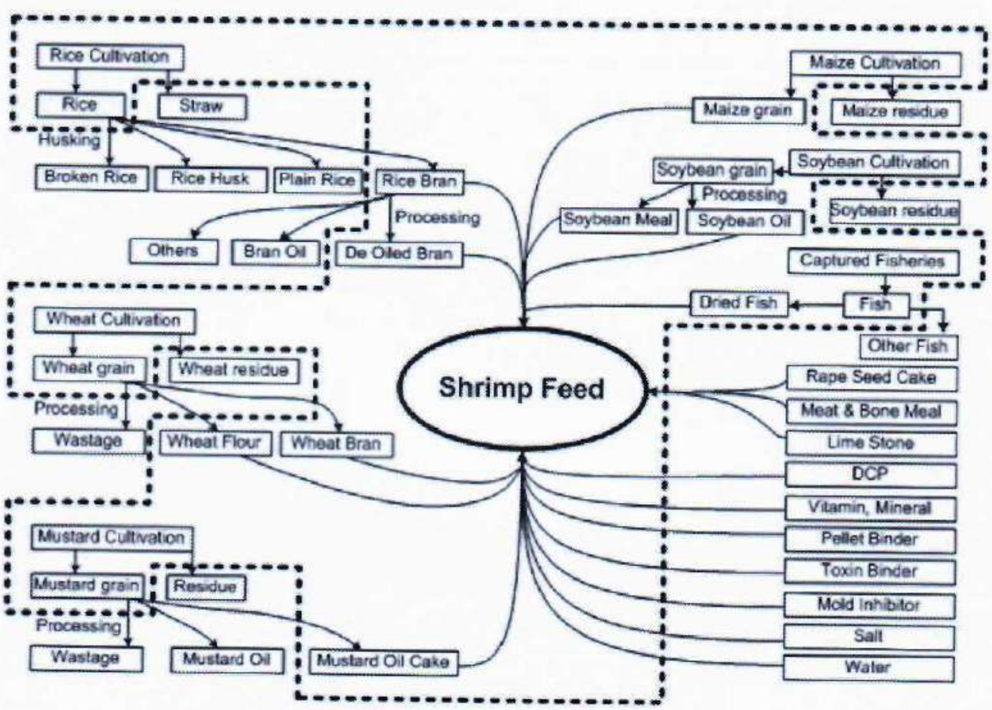

Figure 2: Flowchart of shrimp feed resources in Bangladesh, with the boundary considered for this study defined by the dashed bold line (revised from Nahid 2014).

Table 1. Six farming systems at a glance

Aquaculture inputs (per ha)		WFC prescribed			Others		
		CST (S)	MTT(S+F)	BMP (S+F)	SIS (S)	EXT (S+F)	IEX (S+P+F)
Power supply	Diesel (kg)	145.9	117.1	145.9	208	0.29	31.8
Fertilizer (kg)	Urea	49.4	234.6	370.5	-	45.8	-
	TSP	49.4	209.9	308.8	-	42.7	-
	Mustard oil cake (MOC)	222.3	321.1	259.4	-	8.9	-
	Lime	1049.7	518.7	395.2	500	62.7	183.6
	Molasses	123.5	172.9	12.4	250	-	-
	Yeast	11.12	16.06	0.49	-	-	-
	Rice bran	123.5	172.9	12.4	50	26.4	-
Stocking (No.)	Shrimp PL	74100	37050	49400	148200	109837	20685.6
	Prawn PL	-	-	-	-	-	19882.1
	Fish fry	-	9880	9880	-	9152	767.4
Feed (kg)	Pellet feed	2964	1235	247	7250	-	1208.7
	Dry fish	-	-	-	-	-	85.7
	Wheat bran	-	-	-	-	9.87	51.1
	Rice bran	-	-	-	-	5.64	51.1
	Cooked Broken rice	-	-	-	-	0.18	16.5
	Boiled mixed pulses	-	-	-	-	-	132.1
	Boiled peas pulses	-	-	-	-	-	71.8
	Boiled Maize	-	-	-	-	-	57.6
	Cooked Rice	-	-	-	-	-	150.3
	MOC	-	-	-	-	4.93	-
	Wheat flour made semi	-	-	-	-	-	0.56
	Snail meat	-	-	-	-	-	448.9
Outputs							
kg ha^{-1}	Shrimp	2099.5	617.5	308.8	3750	432.6	109.6
	Prawn	-	-	-	-	-	456.5
	Fish	-	617.5	1235	-	154.4	192.9
Total Kgha^{-1} (Shrimp+Prawn+Fish)		2099.1	1235	1543.75	3750	587	759
million KCal ha^{-1}		1.69	1.22	1.70	3.02	0.54	0.72
Economic FCR (eFCR)		1.41	1.00	0.16	1.93	0.04	3.00
Financial analysis (BDT)	Cost	449278.9	232415.7	114878	1009630	95843.7	254435.6
	Sales	1259700	432250	308750	2250000	274995.4	450253.1
	Profit (Sales-Cost)	810421	199834.3	193871.9	1240370	179151.6	195817.4
	Profit (%)	180.4	85.9	168.7	122.8	186.9	76.9

Source: field survey

Primary data was collected from 21 (Twenty one) farmers of different categories during August to November in 2015 at different locations of South-western Bangladesh for shrimp farming practices. Secondary data was mainly obtained from Nahid (2014). Initial primary data collection helped identify the necessary secondary data needed to identify the environmental and economic inputs and outputs. Beyond primary data specific to the study, secondary data was often consulted when modelling supplying upstream processes. For foreground secondary data (e.g. electricity and transportation), on the other hand, peer-reviewed literature and official reports were consulted and where several sources were available, weighted means were acquired. For processes of assumed lesser importance (based upon previous experiences and literature), or process of high complexity (e.g. oil refining or lorry production), the ecoinvent v.2.2 database was consulted. In cases where substantial emissions were related to ecoinvent processes, these processes were revisited, and when necessary modified to better suit the relevant scenario. The LCI thus included a wide array of data of diverging quality. LCI and LCIA results were finally calculated using CMLCA software (Version 5.2: http://cmlca.eu/).

Brief overview of studied farming systems

In this study 6 (six) shrimp farming systems were identified and evaluated. These are:

a) WFC (World Fish Center: an International NGO) supported farmers:

- i) Closed System Technology (Shrimp): CST (S)
- ii) Modified Traditional Technology (Shrimp + Fish): MTT (S+F)
- iii) Better Management Practice (Shrimp + Fish): BMP (S+F)

b) Other farmers

- i) Semi intensive (Shrimp): SIS (S)
- ii) Extensive (Shrimp + Fish): EXT (S+F)
- iii) Improved extensive (Shrimp + Prawn + Fish): IEX (S+P+F)

Different inputs and outputs per hectare of different shrimp farming systems are given in Table 1. For comparative analysis, shrimp farming systems were categorized in four stages, which were power supply (energy consumption, e.g. diesel, electricity, etc.); stocking (shrimp, prawn, fish); fertilization (urea, TSP, etc.) and feeding (commercial pellet feed, on farm feed etc.).

3. RESULTS

Among the studied farming systems, Semi intensive SIS (S) showed highest and Extensive EXT (S+F) showed lowest yield in respect of shrimp (kg), total output (kg) and total energy (KCal) production (Table 1).

3.1. LCI (Life Cycle Inventory) result:

Table 2 shows major emissions from different farming systems. SIS (S) was responsible for highest CO_2, $N2_O$, NH_3, NO_x, SO_2, N and PO_43- emissions, BMP (S+F) was for highest P emission and IEX (S+P+F) was for highest CH_4 and NO_3 emissions.

Table 2. Major emissions from shrimp farming (per ha production)

	Global warming			Acidification			Eutrophication			
	CO_2	CH_4	N_2O	NH_3	NO_X	SO_2	NO_3	P	N	PO_4^{3-}
MTT (S+F)	2668.93	5.70	4.52	5.98	35.1	7.29	187	124	160	1.60
CST (S)	3343.50	6.75	8.39	10.4	59.8	7.29	342	55.3	123.00	1.48
BMP (S+F)	2623.61	4.38	1.80	2.7	20.6	7.66	69.6	148	157.00	1.81
SIS (S)	5357.47	12.27	18.1	22.4	124	13.4	733	77	253.00	2.43
EXT (S+F)	412.39	0.75	0.14	0.23	2.60	1.16	5.08	32.6	33.70	0.23
IEX (S+P+F)	1910.32	18.2	14.0	16.7	78.1	5.29	810	1.27	0.02	1.10

3.2. LCIA (Life Cycle Impact Assessment) result:

The impact assessment results of different shrimp farming systems scaled to one ha of farming, one KCal of total farming output, and one ton shrimp production are presented in Table 3, 4, and 5, respectively.

Based upon outputs of per ha of farming, global warming and acidification were higher in SIS (S) and eutrophication was higher in BMP (S+F) system (Table 3). Meanwhile, all impacts were lower in EXT (S+F) system.

Table 3. Environmental impacts of shrimp farming (per ha production)

	GWP (kg CO_2 eq.)	Score GWP	AP (kg SO_2 eq.)	Score AP	EP (kg PO_4^{3-} eq.)	Score EP	Total score	Impact position
MTT (S+F)	4160	4	43.10	3	473	5	12	4th
CST (S)	6010	5	68.80	5	267	3	13	5th
BMP (S+F)	3270	2	27.20	2	532	6	10	3rd
SIS (S)	11100	6	142.00	6	438	4	16	Highest
EXT (S+F)	472	1	3.41	1	115	1	3	Lowest
IEX (S+P+F)	3820	3	47.30	4	120	2	9	2nd

Note: lower score refers lower impact

Considering per KCal of total farming output, global warming and acidification were higher in IEX (S+P+F) and eutrophication was higher in MTT (S+F) system (Table 4). EXT (S+F) showed lower impact for global warming and acidification; and SIS (S) showed lower impact for eutrophication.

Table 4. Environmental impacts of shrimp farming (per KCal production)

	GWP (kg CO_2 eq.)	Score GWP	AP (kg SO_2 eq.)	Score AP	EP (kg PO_4^{3-} eq.)	Score EP	Total score	Impact position
MTT (S+F)	0.0034	3	0.000035	3	0.00039	6	12	5th
CST (S)	0.0036	4	0.000041	4	0.00016	2	10	3rd
BMP (S+F)	0.0019	2	0.000016	2	0.00031	5	9	2nd
SIS (S)	0.0037	5	0.000047	5	0.00015	1	11	4th
EXT (S+F)	0.0009	1	0.000006	1	0.00021	4	6	Lowest
IEX (S+P+F)	0.0053	6	0.000066	6	0.00017	3	15	Highest

Note: lower score refers lower impact

Taken into account per ton of shrimp production, global warming and eutrophication results were higher in BMP (S+F) and acidification was higher in MTT (S+F) (Table 5). EXT (S+F) showed lower impact for global warming and acidification; and SIS (S) showed lower impact for eutrophication.

Table 5. Environmental impacts of shrimp farming (per ton shrimp production)

	GWP (kg CO_2 eq.)	Score GWP	AP (kg SO_2 eq.)	Score AP	EP (kg PO_4^{3-} eq.)	Score EP	Total score	Impact position
MTT (S+F)	5770	5	59.9	6	656	5	16	Highest
CST (S)	2860	2	32.8	2	127	2	6	Lowest
BMP (S+F)	6350	6	52.9	4	1030	6	16	Highest
SIS (S)	2950	3	37.9	3	117	1	7	2
EXT (S+F)	1030	1	7.43	1	250	4	6	Lowest
IEX (S+P+F)	4710	4	58.2	5	147	3	12	3

Note: lower score refers lower impact

Based on total score of the studied impact categories EXT (S+F) had the lowest impact for per ha, KCal and ton shrimp production, whereas SIS (S) was responsible for highest impact for per hectare shrimp production; IEX (S+P+F) was for per KCal production; and BMP (S+F) and MTT (S+F) were for higher impact for per ton of shrimp production (Table 3, 4 and 5).

Table 6. Contribution (%) of different farming stages for GWP (per ha production)

Farming practices	GWP (kg CO2 eq.) per ha	% contribution at Farming stages			
		Fertilization	Stocking	Feeding	Power supply
MTT (S+F)	4160.00	43.74	1.78	*37.73*	16.75
CST (S)	6010.00	20.63	2.40	62.54	14.44
BMP (S+F)	3270.00	60.88	3.00	9.57	*26.55*
SIS (S)	11100.00	3.13	2.61	83.05	*11.21*
EXT (S+F)	472.00	47.14	*45.66*	6.83	0.36
IEX (S+P+F)	3820.00	2.75	*10.35*	81.95	4.95

Note: Bold values indicate highest contributions and italic values indicate 2nd highest contributions

Among different farming stages (viz. fertilization, stocking, feeding and power supply), Feeding and fertilization were identified the major contributors for the environmental impacts associated with the different shrimp farming systems (Table 6, 7, 8). Feeding was the largest contributor for global warming in CST (S), SIS (S) and IEX (S+P+F); acidification in MTT (S+F), CST (S), SIS (S) and IEX (S+P+F); and eutrophiction in CST (S), SIS (S) and IEX (S+P+F) systems. Meanwhile, Fertilization had the highest contribution for global warming in MTT (S+F), BMP (S+F) and EXT (S+P); acidification in BMP (S+F), EXT (S+P); and eutrophiction in MTT (S+F), BMP (S+F) and EXT (S+P) systems.

Table 7. Contribution (%) of different shrimp farming stages for AP (per ha production)

Farming practices	AP (kg SO2 eq.) per ha	% contribution at Farming stages			
		Fertilization	Stocking	Feeding	Power supply
MTT (S+F)	43.10	*35.91*	1.11	51.66	11.33
CST (S)	68.80	*12.16*	1.35	77.65	8.84
BMP (S+F)	27.20	58.88	2.33	16.38	*22.41*
SIS (S)	142.00	0.63	1.31	91.97	*6.09*
EXT (S+F)	3.41	44.27	*40.75*	14.63	0.36
IEX (S+P+F)	47.30	0.28	*4.05*	92.86	2.82

Note: Bold values indicate highest contributions and italic values indicate 2nd highest contributions

Table 8. Contribution (%) of different shrimp farming stages for EP (per ha production)

Farming practices	EP (kg PO43- eq.) per ha	% contribution at Farming stages			
		Fertilization	Stocking	Feeding	Power supply
MTT (S+F)	473.00	**81.51**	1.85	*16.39*	0.25
CST (S)	267.00	37.5	0.07	**61.88**	0.55
BMP (S+F)	532.00	**95.2**	1.65	*2.88*	0.27
SIS (S)	438.00	8.65	0.08	**90.79**	0.48
EXT (S+F)	115.00	**93.62**	*5.68*	0.70	0.00
IEX (S+P+F)	120.00	0.03	*6.99*	**92.72**	0.27

Note: Bold values indicate highest contributions and italic values indicate 2nd highest contributions

4. DISCUSSION

As mentioned earlier, six farming systems of two categories of farmers (one was an international NGO WorldFish Center supported farmers and another one was out of their supports) were investigated to know the present status of environmental impact based on three impact categories (global warming, acidification and eutophication). Farming practices were varied due to farm location, area of waterbody, economic status and technological knowledge of farmers, ownership of farm, associated supports etc.

Among the WFC supported farmers, Closed System Technology: CST (S) farmers stocked PCR tested shrimp PL. They stocked 240-320 pcs per decimal (1 decimal = 40 sq.m) where aeration facilities are not available and 400-600 PLs where aeration facilities available. Survival rates of stocking PLs were 75-85% and average production was 1200 - 1800 kg per hectare. Average farm area was 1-3 acre. In Modified Traditional Technology: MTT (S+F), farmers did nursing of PCR tested PLs and then stocked 40-50 juvenile per decimal. Survival rates were 60-70% and average production was 400 - 500 kg per hectare. Average farm area was 5 - 7 acre. In Better Management Practices: BMP (S+F), farmers did not nurse shrimp PLs. They stocked 50-60 Pls per decimal, besides PLs come through tidal water in farm. Survival rates were 30-50% and average production was 250 - 300 kg per hectare. Average farm area was 8- 15 acre.

Semi intensive: SIS (S) farms were seen in very few numbers and data for this study was collected from Gazi Fisheries located at Mongla, Khlna. They stocked 600 PLs per decimal and survival rate was 80-85% with 3000 - 4000 kg per hectare shrimp production. Their farm size was 180 acre with 1.5 acre average pond size. In Extensive: EXT (S+F) system, farmers stock 400-500 PLs per decimal and survival rate was 25-30% with 400 - 450 kg per hectare shrimp production. These farmers rely on natural feed and for this they apply fertilizers into the waterbody. These farms were big sizes having over 10 acres. In Improved Extensive: IEX (S+P+F) system, stocking density was 70-100 PLs per decimal and survival rate was 30-40% with 100 - 120 kg per hectare shrimp production. Average farm size was less than 1 acre. These farmers also cultured Prawn (*Macrobrachium rosenbergii*) and fish (Rohu, Catla, Tilapia, etc.) together with shrimp.

Among different systems, CST (S) and SIS (S) farmers produced only shrimp, whereas IEX (S+P+F) produced prawn and fish besides shrimp, and others produced fish with shrimp. Though CST (S) and SIS (S) farmers were more financially benefited, they were always at risk due to disease outbreak in shrimp farms. Usually these farmers took this risk due to their financial and technological strength. Other farmers, who were comparatively poor, took less risk having stocking of different fish species to recover the lose if disease occur in shrimp.

All WorldFish supported farmers apply fertilizers (to produce natural feed) and supplemental pellet feed in varied ratios, meanwhile SIS (S) farmers fully rely on pellet feed and EXT (S+F) farmers were dependent mainly on natural feed through fertilization with a bit on-farm feed ingredients. IEX (S+P+F) farmers used both pellet feed and on-farm feeds due to prawn was their main production. The eFCR (Practically the weight of feed required to produce one kilogram of live fishat harvest, including mortalities) was highest (1.93) in SIS (S) due to heavily dependent on supplemental feed, and lowest (0.04) in EXT (S+F) due to opposite feeding strategy of SIS (S).

According to Table 2, IEX (S+P+F) had the highest CH4 and NO3emissions; this was due to use of more rice, wheat and pulse based ingredients as feed (Nahid 2014). BMP (S+F) had highest P emissions due to more use of TSP fertilizers. SIS (S) had more contribution for other emissions mainly due to combined effect of more use of different inputs.

According to Table 3, based upon outputs per ha of farming, global warming and acidification were higher in SIS (S); this was due to combined effect of more use of diesel, commercial pellet feed and lime. Eutrophication was higher in BMP (S+F) system due to more use of fertilization ingredients (urea, TSP, MOC). All impacts were lower in EXT (S+F) system, due to comparatively lesser amount used of different ingredients.

According to Table 4, if we consider per KCal of total farming output, IEX (S+P+F) had the highest global warming and acidification impact. Though this farming system produced prawn and fish along with shrimp, using various feed ingredients, total output in KCal was very low (0.74) compare to other systems. Only EXT (S+F) system had lower KCal output than IEX (S+P+F), but in EXT (S+F) system farmers use very lesser amount of inputs compare to other systems. That's why it had lowest global warming and acidification impact. Regarding eutrophication, MTT (S+F) had the highest impact; which was due to more fertilization ingredients used per KCal production than other systems. Alternatively SIS (S) showed lowest eutrophication impact; because of producing highest KCal (3.02) production using very lower amount of fertilization ingredients.

Looking into Table 5, global warming and eutrophication results were higher in BMP (S+F) while considering per ton of shrimp production. This result happened due to using comparatively higher amount of different inputs (especially diesel and fertilizers) to produce lower shrimp production than other systems. Acidification was higher in MTT (S+F), might be due to lower production using more feeding inputs. Likewise per Kcal production, EXT (S+F) had lowest global warming and acidification impact, and SIS (S) showed lowest eutrophication impact due to same reasons.

Analysing Table 3, 4 and 5; EXT (S+F) had the lowest overall impact due to very lower inputs. These farmers stock shrimp PLs from hatchery and through tidal water, then they apply fertilizers for natural feed, wait for growth, and harvest. Though this system had lowest overall environmental impact and profit percentage was highest (Table 1), land utilization was very poor due to lowest production per hectare area. Thus country like Bangladesh which has limited land resources, are losing total aquaculture production, affecting national income and food security. Though SIS (S) system had highest overall environmental impact in respect of per hectare production, it had 4th lowest impact per KCal and 2nd lowest impact per ton of shrimp production. This result indicates that if production is higher per unit area, impact is reduced per unit (e.g. KCal, ton) production. In context of resource utilization this system utilized land more efficiently with highest yield per unit area than other systems, though having moderate profit percentage and huge investment. Farming systems except SIS (S) and CST (S) produced fish besides shrimp, ensured local food security, as shrimp is mainly produced for export market.

According to Cao et al. (2011), one ton live-weight of shrimp production in China generated 3100 kg of CO_2 eq. and 23.1 kg of SO_2 eq., which were similar to per ton of shrimp production in Bangladesh (Table 5). Chinese shrimp production follows intensive and semi-intensive system. The impact was very close to semi intensive system SIS (S) practices in Bangladesh. Also Chinese production system had lower eutrophication impacts (36.9 kg PO_4^{3-} eq.), than the Bangladeshi systems studied in this study, which was probably due to efficient utilization of supplied nutrients (N and P), having higher yield in China. However, it is recommended to avoid comparing values of impact results amongst different LCA studies, as they all are based upon their own methodological choices and assumptions.

It is obvious that each production system must have environmental impact, but the key is how we can reduce this. If we look at different stages of farming systems, feeding (in some cases fertilization, where feed inputs are lower) was the major contributor for environmental impact, which is similar to other previous LCA study in aquaculture (Naylor et al. 2000, Henriksson et al. 2011, Nahid 2014).For long term sustainability of shrimp sector in Bangladesh, production should be economically viable and environmental friendly. To achieve this goal, there is no alternative of increasing production per unit area using modern technology and environmental friendly ingredients at wise. In the following there are some recommendations, need to increase production addressing both economic and environmental sustainability:

1. Should emphasize on natural feed based shrimp farming along with balanced supplementary feed prepared by environmental friendly ingredients.
2. Proper feeding schedule and techniques (e.g. feeding tray) should be followed.
3. Should measure nutrient content (especially N and P) in waterbody for proper fertilization.
4. Integration with different products should be identified to utilize supplied inputs properly.

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