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Identification of plant genetic resources affected by shrimp farming in the southwestern coastal region of Bangladesh

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A B S T R A C T

The main purpose of the study was to identify the plant genetic resources (PGRs) affected by shrimp farming and to determine their magnitude of vulnerability. Data were collected from randomly selected 100 respondents, through personal interview, using an interview schedule, at Dumuria upazila of Khulna district, during 16 November 2009 to 15 February 2010. The fruit PGRs were more affected by shrimp farming than that of timber yielding and other types of PGRs. Among the 18-fruit PGRs available, all were endangered, except indigenous velvet apple, *Diospyros peregrine* (Gaertn.) Gürke, which was in threatened condition. Among the fruit species, banana, *Musa acuminate*; guava, *Psidium guajava* L.; jackfruit, *Artocarpus heterophyllus* Lam.; sapota, *Manilkara zapota* L. and betel nut, *Areca catechu* L. were in highly endangered. Among the 17-timber yielding and other plant species, only 7-PGRs were affected by shrimp farming while majority (10-PGRs) had been available in different extents. Among the vulnerable PGRs, bamboo, *Bambusa bambos* (L.) Voss; flame of the forest, *Delonix regia* (Boj. ex Hook.) Raf.; teak, *Tectona grandis* L.f. and banyan, *Ficus benghalensis* L. were endangered, while Indian ash tree, *Lannea coromandelica* (Houtt.) Merr.; ipil-ipil, *Leucaena leucocephala* (Lam.) de Wit and cool mat, *Schumannianthus dichotomus* (Roxb.) Gagnep. were in threatened condition. In general, the total fruit trees decreased in numbers (-74.17%) after inception of shrimp farming. On the other hand, the total numbers of timber yielding plants increased by 15.45%. From the overall consideration (irrespective of types), the number of plant population decreased (-58.10%) after inception of shrimp farming. It means that the plant species were affected by shrimp farming and became endangered.

Keywords: Plant genetic resources, Identification, Shrimp farming, Vulnerability

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Introduction

Bangladesh, being an agro-based country and having a vast fertile plain land, has not yet achieved a sustainable self-sufficiency in food production. Like other essential commodities, it is importing a large quantities of food grains every year to meet up its food shortage. However, a few agricultural, industrial and fisheries products are being exported; of which freezing shrimp is one of the major components (Paul, 1996). In Bangladesh, the sectorial contribution by shrimp export to the GDP was 8% in 1996-97 while the same was 6.97% in 1997-98 (Anonymous, 1998). The foreign earnings by crustaceans, which include shrimp, were 12.8% in 2015-16 increased to 13.56% in 2016-17 (Anonymous, 2019). Besides, shrimp farming is one of the fastest growing components of the global aquaculture. In 1988, the world's shrimp farmers produced 7,37,000 tons of shrimp worth of an estimated USD 6 billion (Rosenberry, 1998). The culture of shrimp has become very much popular at the coastal region of the country, considering it as a unique means of income generation. This popularity has come from its high economic return.

The shrimp culture is locally termed as 'gher' [the water-bodies of shrimp/prawn farm are known as "gher" (Akter *et al.*, 2019)] located mostly at the southwestern part of the country (southern part of Satkhira, Khulna and Bagerhat districts). The shrimp culture/gher business has become blessings for a small segment of our population, but a curse for the vast majority. The few

beneficiaries are almost property owners who can afford a lot of money, because it requires high initial investment. This includes taking land lease from the farmers, making embankment around the land, erection of a number of small cottage for night guard, recruitment of support service personnel, purchasing of post larvae (daughter shrimp) and other miscellaneous costs. The cultural procedure at first involves in making embankment around the land and then the whole area of land is filled up by the saline water from the river, which acts as cultural media for growth and development of post larvae (Paul, 1996). This artificial stagnant of saline water in a particular area of land creates enormous problems on normal life of poor village dwellers. Firstly, the land becomes uncultivable for usual crop plants. Secondly, the vast land is occupied by water, so, the cattle's do not get grassland and ultimately the cattle owners become compelled to sell their cattle, as a result, cow's milk become unavailable. Thirdly, the village dwellers generally use cow dung and paddy residues as a cheap means of fuel, but at present, due to its unavailability, they become dependent on costly firewood. Fourthly, saline water does not retain within a confined area, percolation and seepage of water takes place which create another major problems to the existence of fruit and valuable trees and also leading to the extinction of fresh-water fish, including aquatic animals and plants in the small ponds of poor village dwellers. Paul and Vogl (2011) addressed that shrimp farming environmental impacts such as mangrove degradation, salt-water intrusion, sedimentation, pollution and disease outbreaks had been found to be obstacles for the sustainable development of farming. In this way, shrimp culture creates a direct threat to the existence of poor families in the area, and makes a natural and/or ecological imbalance (Karim, 2000).

Considering these viewpoints, an attempt was made to conduct a study entitled "Identification of Plant Genetic Resources Affected by Shrimp Farming in the Southwestern Coastal Region of Bangladesh" to i) describe the socioeconomic characteristics of the respondents; ii) identify the PGRs' availability in the study area; and iii) determine the extent of vulnerability of PGRs caused by shrimp farming.

Methodology

The research was designed to identify the PGRs as affected by shrimp farming and to investigate the extent of vulnerability of the PGRs caused by shrimp farming. The two main centers of shrimp production are located at (a) Khulna, Satkhira, Bagerhat districts in the Southwest; and (b) Chittagong and Cox's bazaar districts in the Southeast. Rahman *et al.* (1994) highlighted that about 80% area of Khulna, Bagerhat, and Satkhira are under shrimp culture in Bangladesh, and noticed a threefold increase in the last decade. The area under shrimp culture had increased from 52,000 ha in 1982-83 to 141,000 ha in 1999-00, and about 75% of this land is located in the Khulna, Bagerhat and Satkhira districts in the southeastern region of the country (Mazid, 2002). It now covers about 1,45,000 hectares of land sprawled over 9,000 farms, 18% of total farms. In Bangladesh, shrimp cultivation has been spreading in the coastal regions. Fourteen southern administrative districts are sharing the whole shrimp cultivation coverage. For this study, Dumuria upazila (sub-district) under Khulna district was purposively [as this was an epicenter of shrimp farming] selected as the locale of the study.

The key role-playing members of the farmer's family were selected for answering. The researchers, when went to collect data, asked the farmers whether there is any PGRs in his homestead or not. If the answer was yes (i.e., they have owned PGRs), the individual was selected as sample of the study. In this way, 100 respondents were selected by simple random sampling method. The distributions of sample farmers in the selected unions (smallest administrative unit) are shown in the Table 1.

Table 1. Sampling of the respondents.

Name of the upazila	Name of the union	Number of the selected farmers
Dumuria	Kharnia	42
	Atlia	37
	Dumuria	21
Total		100

Data were collected with the help of pretested interview schedule by the researchers following personal interview method. Data were collected from the respondents during 16 November 2009 to 15 February 2010. Hossain and Hasan (2017) reported that, in parallel with the significant contribution of the shrimp sector to the local and national economy, it has caused some negative impacts on local ecosystems. Ecological impacts include some deterioration of soil and water quality, depletion of mangrove forest, decrease in population of native fish and shellfish species,

intrusion of saline water, water pollution and changes to local hydrology. This proves that the scenario of degradation is still worsening. The collected data were cross checked by focus group discussion (FGD).

Data were collected on some of the selected characteristics of the respondents such as age, education, family size, farm size, annual income, farming experience, agricultural knowledge, organizational participation, cosmopolitanism, training and extension media contact. Data were also collected on PGRs as affected by shrimp farming and their extent of vulnerability. The respondents were asked directly to provide information regarding the PGRs available at their homestead before and after inception of shrimp farming. The extent of vulnerability was determined by three points rating scale developed by Ahmed (2003).

Rating scale based on nature of vulnerability	Percent of vulnerability
Threatened	≤50
Endangered	51-99
Extinct	100

Threatened means species still abundant in its natural range but is declining in number likely to become endangered, where endangered means species having so few in number that the species could soon become extinct overall or most of its natural range while extinct means the loss of an entire species (Ahmed, 2003).

An opposite scale was also followed to observe the availability of PGRs in the study area as developed by Ahmed (2003). The scales are as follows:

Rating scale based on nature of availability	Percent of availability
Fairly available	≤50
Moderately available	51-99
Extremely available	100

After completion of survey, all the interview schedules were compiled for processing of data. At the beginning of the data processing, all the qualitative data were converted into quantitative form by means of suitable code and score whenever necessary. Local units were converted into standard units. In several paradigms, indices and scales were constructed through the simple accumulation of scores allocated to individual or pattern of attributes. Statistical Package for Social Sciences (SPSS) was used to analyze the data. Statistical treatment such as number, percent, range, mean and standard deviation were used to describe and interpret the results.

Results and Discussion

Socioeconomic characteristics of the respondents

Majority (62%) of the respondents belonged to middle aged (36-50 years) group followed by old aged (>50 years) group (24%) and only 14% of the respondents belonged to young aged (≤35 years) group. Average age of the respondents was around 45 years (Table 2). The highest numbers of respondents (34%) were in the primary level (1-5 years of schooling) of education followed by secondary level (6-10 years, 31%), illiterate (14.6%), higher secondary (11-12 years, 6%) and graduate (>12 years, 4%) level of education (Table 2). Majority (60%) of the respondents had medium sized family (5-7 members) followed by large sized family (>7 members, 25%) and only 15% respondents had small sized family (≤4 members) (Table 2). The average family size (6.28) of the respondents is higher than that of national average (5.6) (Anonymous, 2018), and the trend of family size is gradually lowering all over the country. It implies that the family planning activities in the study area were not so strong. The concerned department may take immediate step to create awareness among the people of the study area about planned family life. Most (85%) of the respondents were small landholders (0.21 to 1.0 ha). The subsequent respondents encircled medium land holding (1.01 to 3.0 ha, 12%) and only 3% respondents were marginal landholders (0.02 to 0.20 ha). None of them was landless (Table 2). Majority (52%) of the respondents belonged to medium income (50,000 to 1,00,000 BDT year^{-1}) group. More than one-fourth (26%) of them belonged to low income group (<50,000 BDT year^{-1}) and only 22% fall in high income group (>1,00,000 BDT year^{-1}) (Table 2). About half of the respondents (49%) had no organizational participation followed by (42%) low participation while only 9% of them had medium participation. None of the respondents had higher organizational participation (Table 2). Most of the respondents considered to have more relation with NGO leaded Samities (group of people with same interest) than other selected organizations.

Majority (63%) of the respondents were in the category of medium cosmopolitanism while 31% were low cosmopolite and only 6% respondents were high cosmopolite (Table 2). Most (78%) of the respondents had medium scale extension media contact followed by low scale extension media contact (19%) and only 3% respondents maintained high scale extension media contact (Table 2). The respondents were exposed to two types of training either related to crop production and/or fisheries. Highest proportion (16%) of the respondents was exposed to training related to agriculture followed by fisheries (11%)(Table 2). Most of the respondents possessed medium agricultural knowledge followed by low agricultural knowledge (9%). Only a few (4%) of the respondents possessed high agricultural knowledge (Table 2).

Table 2. Distribution of the respondents according to their selected characteristics.

Characteristics (Measuring unit)	Categories	Score	Respondents (N=100) Percent	Range	Mean ± SD
Age (Years)	Young aged	≤35	14	25-66	45.39 ± 9.90
	Middle aged	36-50	62		
	Old aged	>50	24		
Educational qualification (Year of schooling)	Illiterate	0	12	0-14	5.4 ± 4.03
	Can read and write	1/2	13		
	Primary level	1-5	34		
	Secondary level	6-10	31		
	Higher secondary level	11-12	6		
	Graduate level	>12	4		
Family size (Number)	Small sized family	1-4	15	2-11	6.28 ± 1.93
	Medium sized family	5-7	60		
	Large sized family	>7	25		
Farm size (ha)	Landless	<0.02	0	0.14-5.89	0.83 ± 0.83
	Marginal land holder	0.02-0.20	0		
	Small land holder	0.21-1.00	85		
	Medium land holder	1.01-3.00	12		
	Large land holder	>3.00	3		
Annual income ('000' BDT)	Low income	≤50	26	20-430	81.13 ± 64.96
	Medium income	50 – 100	52		
	High income	>100	22		
Organizational participation (Score)	No participation	0	49	0-3	0.64 ± 0.74
	Low participation	1	42		
	Medium participation	2-3	9		
	High participation	>3	0		
Cosmopolitanism	Low cosmopolite	≤10	31	6-16	11.36 ± 2.16
	Medium cosmopolite	10-15	63		
	High cosmopolite	>15	6		
Extension media contact (Score)	Low extension contact	0-10	19	4-23	13.19 ± 3.23
	Medium extension contact	11-20	78		
	High extension contact	>20	3		
Training (Score)	Fisheries training	16			
	Agricultural training	11			
	Others	0			
Agricultural knowledge (Score)	Low knowledge	<15	9	11-33	22.45 ± 4.55
	Medium knowledge	15-30	87		
	High knowledge	>30	4		

Plant genetic resources available at homestead of the study area

For sound living and friendly environment, it is suggested by the ecologist to cover 25% of the total land area by trees and/or other vegetation in a country. The true tree cover in Bangladesh is around 7%; but including homestead and other tree cover, it accounts around 17.4% (Rahman, 2020). Therefore, it is very essential to plant trees to increase tree cover area, which will ultimately help us for a better and healthy living.

To have an idea of tree cover in the homestead of the study area the respondents were asked to mention the number of trees available in their homesteads in different years (BISF-1989 and AISF- i.e., 1999 and 2009) [Before and After of Inception of Shrimp Farming]. The average number of trees per homestead in 2009 in the study area was 21.50 while the number before inception of shrimp farming (in 1989) was 51.31, irrespective of species and types of plants (Figure 1 and Supp. Table 1).

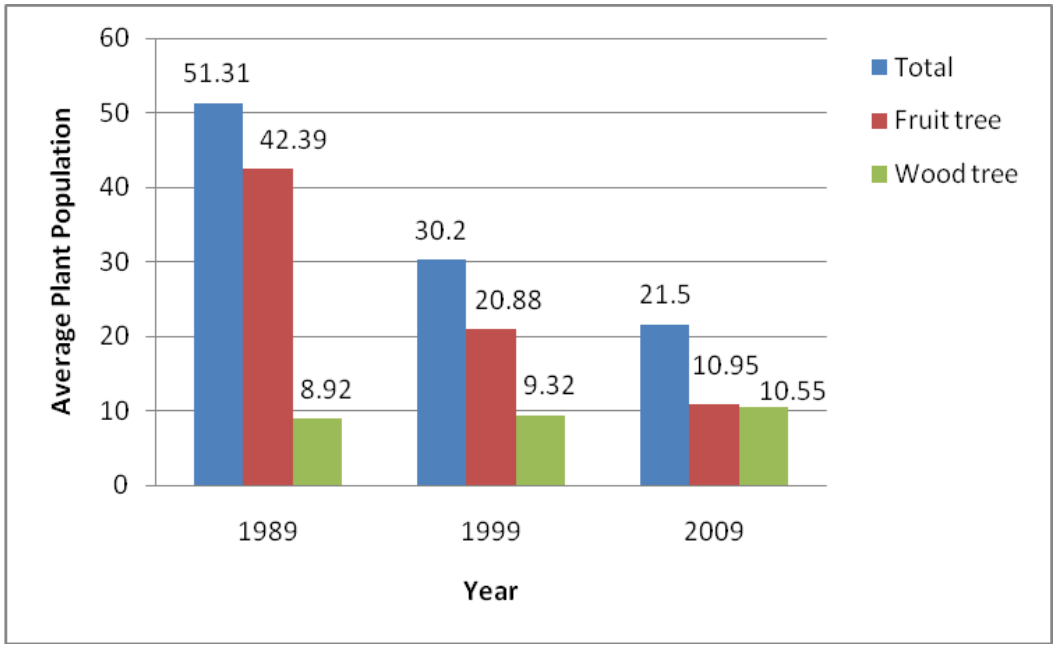

Fig. 1. Average plant population per homestead in the study area.

A wide range of plant species (33 and 35) were fairly available in the homestead both in pre-project (1989) and post project (1999 and 2009) time respectively (Supp. Table 1). The most dominant plant species in the study area irrespective of time is coconut tree. The trend of number of some major fruit plant species are shown in Figure 2, which are adversely affected by salinity due to shrimp farming.

The coconut, *Cocos nucifera* L. tree ranked first from population point of view both in pre-project and post project time and it was followed by banana, *Musa acuminate* Colla; sapota, *Manilkara zapota* (L.) P. Royen and mango, *Mangifera indica* L. However, a prestigious number of fruit trees are available in the study area, but their production and growth are affected by salinity resulting from shrimp farming. In the study area, the coconut production was 70-80 drupes tree^{-1}year^{-1} in before inception of shrimp farming which was much higher than the national average i.e., 20 drupes tree^{-1} year^{-1} (Anonymous, 1998). Although the production has already reduced to 20-30 drupes tree^{-1} year^{-1} it is still higher than that of national average. Salinity along with water logging severely affected the production of fruits as well as the trees and other vegetation in the study area.

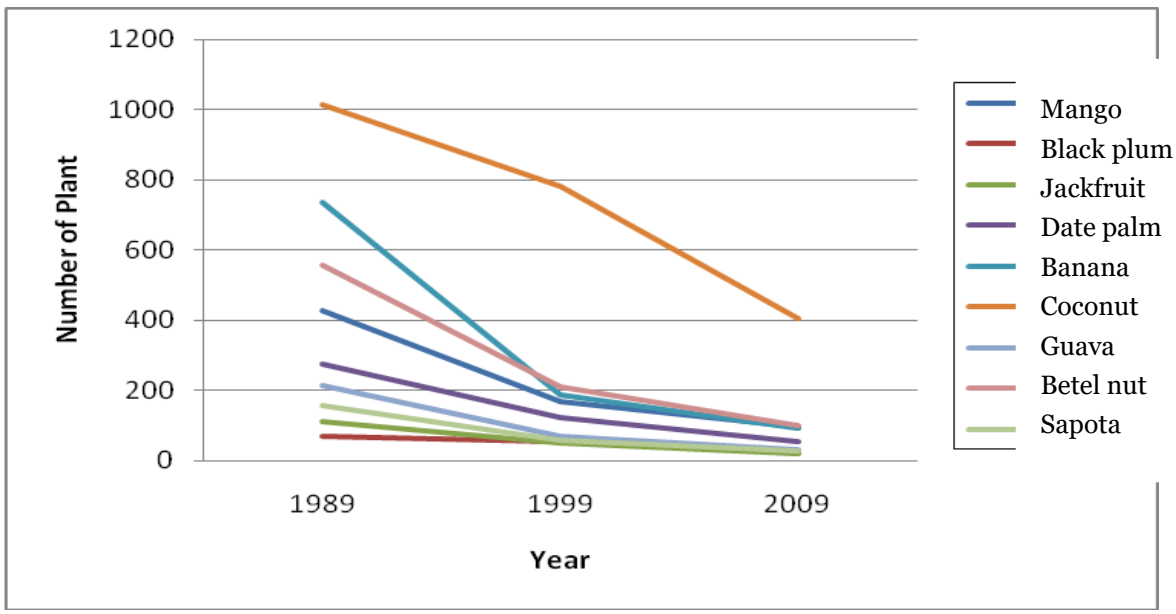

Fig. 2. Major fruit plant population in the study area.

As the fruit plants were more affected by salinity, the people of the area preferred timber-yielding plants for their homestead. Consequently, the numbers of some timber yielding and other plants (viz. mahogany, *Swietenia macrophylla* King; gum arabic tree, *Acacia nilotica* (L.) Willd. exDelile; neem, *Azadirachta indica* A. Juss.; raintree, *Samanea saman* (Jacq.) Merr.; Indian rosewood, *Dalbergia sissoo* Roxb. have increased over time in the study area (Figure 3 and Figure 4, Supp. Table 1). It was observed that timber and other plants are less affected than fruit plants. For this reasons mahogany especially got a tremendous acceptability in the study. A similar type of result was found by Ahmed (2003).

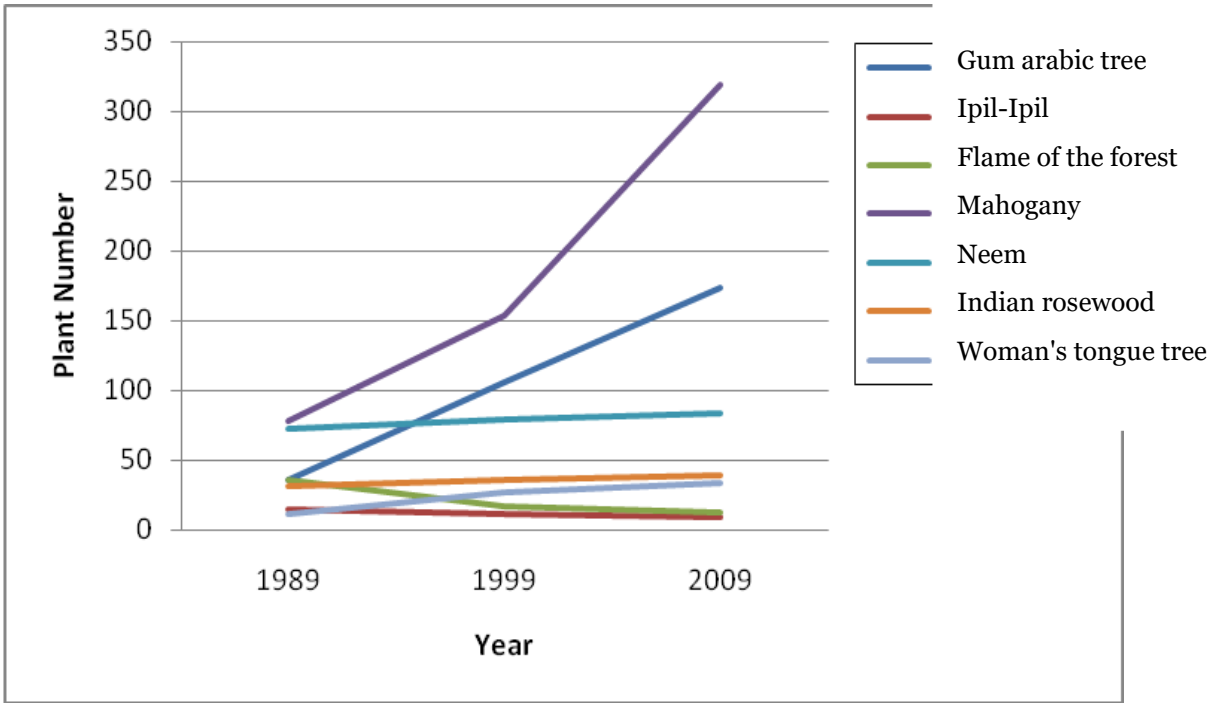

Fig. 3. Major timber tree population in the study area.

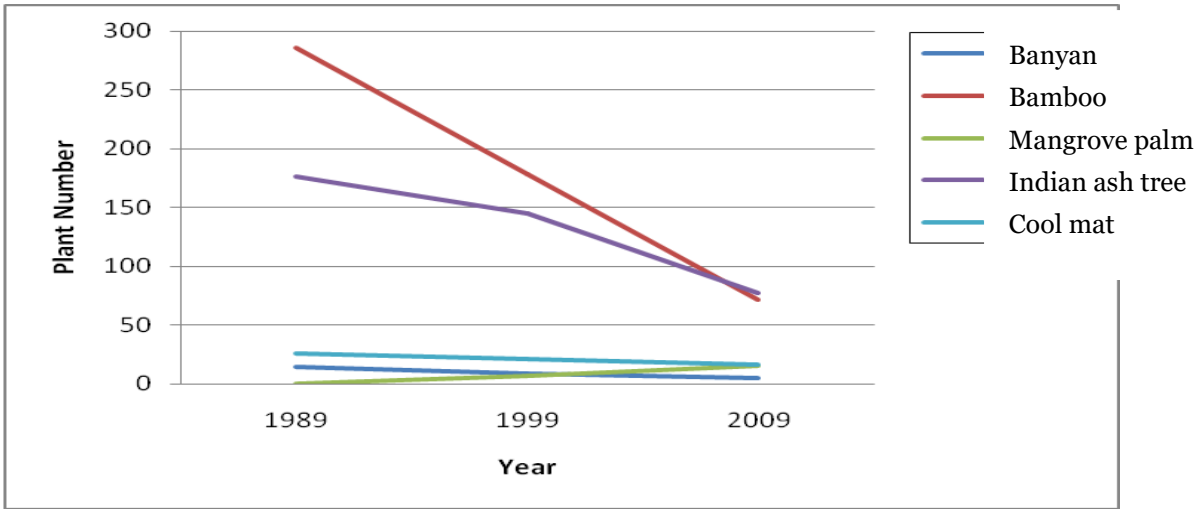

Fig. 4. Others tree population in the study area.

Plant genetic resources affected by shrimp farming

Results presented in Table 3 indicate that among the 18-fruit plant species available in the study area, all most all except indigenous velvet apple, *Diospyros peregrine* (Gaertn.) Gürke were in vulnerable condition i.e., in endangered condition. Indigenous velvet apple was in threatened condition. Among the fruit species, banana, *Musa acuminate* Colla; guava, *Psidium guajava* L.; jackfruit, *Artocarpus heterophyllus* Lam.; sapota, *Manilkara zapota* (L.) P. Royen and betel nut, *Areca catechu* L. were in highly endangered condition due to continuous intrusion of high saline water in the study area needed for shrimp farming (Table 3).

It is also observed from Table 3 that among the 17–timber yielding and other plant species, only 7–PGRs were affected by shrimp farming while majority (10–PGRs) became fairly available to different extent. Among the vulnerable PGRs, bamboo, *Bambusa bambos* (L.) Voss; flame of

the forest, *Delonix regia* (Boj. Ex Hook.) Raf.; teak, *Tectona grandis* L.f. and banyan, *Ficus benghalensis* L. were in endangered condition while Indian ash tree, *Lannea coromandelica* (Houtt.) Merr.; ipil-ipil, *Leucaena leucocephala* (Lam.) de Wit and cool mat, *Schumannianthus dichotomus* (Roxb.) Gagnep. were in threatened condition.

Results presented in Table 3 indicate that in general the total fruit trees decreased in numbers (-74.17%) after inception of shrimp farming. It means that it was affected by shrimp farming and became vulnerable (endangered). On the other hand, the total numbers of timber yielding plants increased by 15.45% after inception of shrimp farming. It means that, it was not affected except some exception and became fairly available. From overall consideration (irrespective of types), the number of plant population decreased (-58.10%) after inception of shrimp farming. It means that the plant species were affected by shrimp farming and became endangered.

Conclusion and Recommendation

The total number of fruit trees decreased after inception of shrimp farming. That means, it was affected by shrimp farming and became endangered. However, the total numbers of timber yielding plants increased after inception of shrimp farming. That means, it was not affected except some exception and became fairly available. Considering the overall scenario, the average number of plant population decreased (-58.10%), irrespective of types, after inception of shrimp farming. Thus, it might be concluded that the plant species were affected by shrimp farming and became endangered. Based on the findings, it is recommended that, indiscriminate saline water intrusion in the ghres for shrimp farming should be managed in such a way that it would not cause any harm to the existing PGRs.

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Conflict of interest

There is none competing for the interests regarding the submitted manuscript, and the conducted research, except the authors mentioned in the author list.

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Table 3. Vulnerability of PGRs in the study area.

Bangla Name / Common Name	Scientific Name	Availability of Plant Population (%)			Percentage of Vulnerability (-)/ Availability (+)		Remarks
		BISF	AISF		AISF		
		1989	1999	2009	1999-2009	2009	
1. Aam / Mango	*Mangifera indica* L.	426 (100)	170 (39.91)	97 (22.77)	-256 (-60.09)	-329 (-77.23)	Endangered
2. Atafol / Custard apple	*Annona reticulata* L.	42 (100)	22 (52.38)	10 (23.81)	-20 (-47.62)	-32 (-76.19)	Endangered
3. Dalim / Pomegranate	*Punica granatum* L.	32 (100)	17 (53.13)	11 (34.38)	-15 (-46.87)	-21 (-65.62)	Endangered
4. Deshigaab / Indigenous velvet apple	*Diospyros peregrine* (Gaertn.) Gürke	13 (100)	10 (76.92)	9 (69.23)	-3 (-23.08)	-4 (-30.77)	Threatened
5. Dumur / Common fig	*Ficus carica* L.	17 (100)	11 (64.71)	7 (41.18)	-6 (-35.29)	-10 (-58.82)	Endangered
6. Jaam / Black plum	*Syzygium cumini* (L.) Skeels.	71 (100)	55 (77.46)	23 (32.39)	-16 (-22.54)	-48 (-67.61)	Endangered
7. Kachkola / Cooking plantain	Musa × paradisiaca L.	159 (100)	123 (77.36)	68 (42.77)	-36 (-22.64)	-91 (-57.23)	Endangered
8. Kathal / Jackfruit	*Artocarpus heterophyllus* Lam.	111 (100)	48 (43.24)	19 (17.12)	-63 (-56.76)	-92 (-82.88)	Endangered
9. Khejur / Date palm	*Phoenix dactylifera* L.	276 (100)	122 (44.20)	55 (19.93)	-154 (-55.80)	-221 (-80.07)	Endangered
10. Kola / Banana	*Musa acuminata* Colla	737 (100)	188 (25.51)	93 (12.62)	-549 (-74.49)	-644 (-87.38)	Endangered
11. Kul / Jujube	*Ziziphus jujube* Mill.	168 (100)	71 (42.26)	55 (32.74)	-97 (-57.74)	-113 (-67.26)	Endangered
12. Narikel / Coconut	*Cocos nucifera*L.	1012 (100)	778 (76.88)	403 (39.82)	-234 (-23.12)	-609 (-60.18)	Endangered
13. Pepe / Papaya	*Carica papaya* L.	113 (100)	53 (46.90)	37 (32.74)	-60 (-53.10)	-76 (-67.26)	Endangered
14. Peyara / Guava	*Psidium guajava* L.	214 (100)	68 (31.78)	31 (14.49)	-146 (-68.22)	-183 (-85.51)	Endangered
15. Sajina / Drumstick tree	*Moringa oleifera* Lam.	56 (100)	33 (58.93)	16 (28.57)	-23 (-41.07)	-40 (-71.43)	Endangered
16. Sofeda / Sapota	*Manilkara zapota* (L.) P.Royen	555 (100)	209 (37.66)	98 (17.66)	-346 (-62.34)	-459 (-82.34)	Endangered
17. Supari / Betel nut or Areca nut	*Areca catechu* L.	155 (100)	59 (38.06)	28 (18.06)	-96 (-61.94)	-127 (-81.94)	Endangered
18. Tal / Palmyra palm	*Borassus flabellifer* L.	82 (100)	51 (62.20)	35 (42.68)	-31 (-37.80)	-47 (-57.32)	Endangered
Total		4239	2088	1095			Endangered
19. Babla / Gum arabic tree	Acacia nilotica (L.) Willd.	36 (20.81)	106 (61.27)	173 (100.00)	67 (38.73)	137 (79.19)	Moderately Available
20. Bot / Banyan	Ficus benghalensis L.	14 (100)	9 (64.29)	5 (35.71)	-5 (-35.71)	-9 (-64.29)	Endangered
21. Bash / Bamboo	*Bambusa bambos* (L.) Voss	286 (100)	178 (62.24)	72 (25.17)	-108(-37.76)	-214 (-74.83)	Endangered
22. Ipil-Ipil	Leucaena leucocephala (Lam.)	15 (100)	11 (73.33)	9 (60.00)	-4 (-26.67)	-6 (-40.00)	Threatened
23. Jiga / Indian ash tree	*Lannea coromandelica* (Houtt.)	176 (100)	145 (82.39)	77 (43.75)	-31 (-17.61)	-99 (-43.75)	Threatened
24. Krishnachura / Flame of the forest	*Delonix regia* (Boj. ex Hook.) Raf.	36 (100)	17 (47.22)	12 (33.33)	-19(-52.78)	-24 (-66.67)	Endangered
25. Mahogany	*Swietenia macrophylla* King	78 (24.45)	154 (48.28)	319 (100.00)	165 (51.72)	241 (75.55)	Moderately Available
26. Neem	*Azadirachta indica* A.Juss.	72 (85.71)	79 (94.05)	84 (100.00)	5 (5.95)	12 (14.29)	Moderately Available
27. Rain tree	*Samanea saman* (Jacq.) Merr.	65 (67.71)	73 (76.04)	96 (100.00)	23 (23.96)	31 (32.29)	Moderately Available
28. Segun / Teak	*Tectona grandis* L.f.	9 (100)	4 (44.44)	3 (33.33)	-5 (-55.56)	-6 (-66.67)	Endangered
29. Gewa / Milky mangrove	*Excoecaria agallocha* L.	00	7 (53.85)	13 (100.00)	6 (46.15)	13 (100.00)	Extremely Available
30. Golpata / Mangrove palm	*Nypa fruticans* Wurmb	00	7 (46.67)	15 (100.00)	8 (53.33)	15 (100.00)	Extremely Available
31. Bet / Cool mat	*Schumannianthus dichotomus* (Roxb.) Gagnep.	26 (100)	21 (80.77)	16 (61.54)	-5(-19.23)	-10(-38.46)	Threatened
32. Sissoo / Indian rosewood	*Dalbergia sissoo* Roxb.	31 (79.49)	36 (92.31)	39 (100.00)	3 (7.69)	8 (20.51)	Fairly Available
33. Bayin / Indian mangrove	*Avicennia officinalis* L.	9 (24.32)	23 (62.16)	37 (100.00)	14 (37.84)	28 (75.68)	Moderately Available
34. Kewra / Screw pine	*Sonneratia apetala* Buch.-Ham.	28 (53.85)	36 (69.23)	52 (100.00)	16 (30.76)	24 (46.15)	Fairly Available
35. Sirish / Woman's tongue tree	*Albizia lebbeck*(L.) Benth.	11 (33.33)	26 (78.79)	33 (100.00)	7 (21.21)	22 (66.67)	Moderately Available
Total		892	932	1055			Fairly Available

Serial 1-18: fruit tree species; 19-35: timber and other tree species

Supplementary Table 1. Availability of plant population in the study area.

Bangla Name / Common Name	Scientific Name	Plant Population								
		Before Inception of Shrimp Farming (BISF)			After Inception Shrimp of Farming (AISF)					
					10 Years			20 Years		
		Total	Mean	Range	Total	Mean	Range	Total	Mean	Range
1. Aam / Mango	*Mangifera indica* L.	426	4.26	0-18	170	1.70	0-7	97	0.97	0-5
2. Atafol /Custard apple	*Annona reticulata* L.	42	0.42	0-2	22	0.22	0-3	10	0.10	0-2
3. Dalim / Pomegranate	*Punica granatum* L.	32	0.32	0-2	17	0.17	0-2	11	0.11	0-1
4. Deshigaab / Indigenous velvet apple	*Diospyros peregrine* (Gaertn.) Gürke	13	0.13	0-1	10	0.10	0-1	9	0.90	0-1
5. Dumur / Common fig	*Ficus carica* L.	17	0.17	0-1	11	0.11	0-1	7	0.07	0-1
6. Jaam / Black plum	*Syzygium cumini* (L.) Skeels.	71	0.71	0-3	55	0.55	0-2	23	0.23	0-1
7. Kachkola / Cooking plantain	Musa × paradisiaca L.	159	1.59	0-12	123	1.23	0-6	68	0.68	0-4
8. Kathal / Jackfruit	*Artocarpus heterophyllus* Lam.	111	1.11	0-3	48	0.48	0-2	19	0.19	0-2
9. Khejur / Date palm	*Phoenix dactylifera* L.	276	2.76	0-9	122	1.22	0-5	55	0.55	0-3
10. Kola / Banana	*Musa acuminata* Colla	737	7.37	0-22	188	1.88	0-8	93	0.93	0-5
11. Kul / Jujube	*Ziziphus jujuba* Mill.	168	1.68	0-6	71	0.71	0-4	55	0.55	0-3
12. Narikel / Coconut	*Cocos nucifera* L.	1012	10.12	0-20	778	5.78	0-8	403	2.03	0-5
13. Pepe / Papaya	*Carica papaya* L.	113	1.13	0-5	53	0.53	0-2	37	0.37	0-2
14. Peyara / Guava	*Psidium guajava* L.	214	2.14	0-7	68	0.68	0-4	31	0.31	0-3
15. Sajina / Drumstick tree	*Moringa oleifera* Lam.	56	0.56	0-3	33	0.33	0-2	16	0.16	0-2
16. Sofeda / Sapota	*Manilkara zapota* (L.) P.Royen	555	5.55	0-16	209	2.09	0-4	98	0.98	0-3
17. Supari / Betel nut or Areca nut	*Areca catechu* L.	155	1.55	0-8	59	0.59	0-5	28	0.28	0-2
18. Tal / Palmyra palm	*Borassus flabellifer* L.	82	0.82	0-3	51	0.51	0-1	35	0.35	0-1
Total		4239			2088			1095		
19. Babla / Gum arabic tree	*Acacia nilotica* (L.) Willd.	36	0.46	0-2	106	1.06	0-5	173	1.73	0-8
20. Bot / Banyan	*Ficus benghalensis* L.	14	0.14	0-1	9	0.09	0-1	5	0.05	0-1
21. Bash / Bamboo	*Bambusa bambos* (L.) Voss	286	2.86	0-18	178	1.78	0-11	72	0.72	0-6
22. Ipil-Ipil	*Leucaena leucocephala* (Lam.)	15	0.15	0-1	11	0.11	0-1	9	0.09	0-1
23. Jiga / Indian ash tree	*Lannea coromandelica* (Houtt.)	176	1.76	0-9	145	1.45	0-5	77	0.77	0-5
24. Krishnachura / Flame of the forest	*Delonix regia* (Boj. ex Hook.) Raf.	36	0.36	0-2	17	0.17	0-1	12	0.12	0-1
25. Mahogany	*Swietenia macrophylla* King	78	0.78	0-2	154	1.54	0-6	319	3.19	0-15
26. Neem	*Azadirachta indica* A.Juss.	72	0.72	0-3	79	0.79	0-5	84	0.84	0-6
27. Rain tree	*Samanea saman* (Jacq.) Merr.	65	0.65	0-2	73	0.73	0-3	96	0.96	0-3
28. Segun / Teak	*Tectona grandis* L.f.	9	0.09	0-1	4	0.09	0-1	3	0.03	0-1
29. Gewa / Milky mangrove	*Excoecaria agallocha* L.	0	0	0-0	7	0.07	0-1	13	0.13	0-1
30. Golpata / Mangrove palm	*Nypa fruticans* Wurmb	0	0	0-0	7	0.07	0-1	15	0.15	0-3
31. Bet / Cool mat	*Schumannianthus dichotomus* (Roxb.) Gagnep.	26	0.26	0-2	21	0.21	0-1	16	0.16	0-1
32. Sissoo / Indian rosewood	*Dalbergia sissoo* Roxb.	31	0.31	0-1	36	0.36	0-1	39	0.39	0-2
33. Bayin / Indian mangrove	*Avicennia officinalis* L.	9	0.09	0-1	23	0.23	0-1	37	0.37	0-2
34. Kewra / Screw pine	*Sonneratia apetala* Buch. Ham.	28	0.28	0-1	36	0.36	0-1	52	0.52	0-2
35. Sirish / Woman's tongue tree	*Albizia lebbeck* (L.) Benth.	11	0.11	0-1	26	0.26	0-1	33	0.33	0-1
Total		892			932			1055		
Grand Total		5131			3020			2150		

Serial 1-18: fruit trees; 19-35: timber tree