

Soil, Plant Species and Encroachment Status of Sal Forest in Bangladesh

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ABSTRACT

The study investigated the soil fertility status of denuded encroached forest and naturally vegetation covered forest area, plant species diversity and structural composition, encroachment status of BNP and MNP ranges of Sal forest. Soil fertility status was measured before (March to April) and after (September to October) the monsoon. Soil samples were collected before monsoon (March to April) and after monsoon (September to October) from Sal tree covered areas and from deforested areas only after the monsoon. In all situations soil samples were collected from 0-15 cm and 16-30 cm depth. Physico-chemical characters such as soil texture, colour, pH, organic matter (%), nitrogen (%), phosphorus (ppm), potassium (meq./100g) and sulphur (ppm) were estimated. The study revealed that physico-chemical characteristics of Bhawal and Madhupur Sal forest areas were almost similar but the soil of upper layer (0-15cm depth) was more fertile than deeper soil (16-30cm depth). The physico-chemical characteristics of soil of denuded and encroached areas of both Bhawal and Madhupur forests were severely declined compared to Sal tree covered areas soil. All physico-chemical characteristics (soil texture, colour, pH, organic matter, nitrogen, phosphorus, potassium and sulphur) of denuded and encroached areas soil were low in both the forests compared to naturally sal tree covered areas in both the situations i. e., surface (0-15cm depth) and sub surface (16-30cm depth) soil. For estimating the plant species diversity and structural composition, 'Count Quadrats or list-count quadrats' method was used. Total 80 quadrats (10 m x 10 m) were surveyed of which 30 from BNP range and 50 from MNP range for collecting plants species information. In the BNP range, total 49 plant species were identified of which 24 trees, 4 shrubs, 7 climbers and 14 herbs species. These 49 plants species of this Sal forest belong to 30 families and 43 genera. In the MNP range of Sal forest area, total 112 plant species were identified of which 60 trees, 9 shrubs, 19 climbers and 23 herbs species. These 112 plant species of Madhupur Sal forest belong to 50 families and 93 genera. Structural composition were evaluated with regard to their density, relative density, frequency, relative frequency, abundance, dominance, relative dominance of a species, total basal

coverage, importance value index (IVI), diversity index and beta diversity. Total 47 plant species were similar between this BNP and MNP range of Sal forest and beta diversity index was 0.584. Considering all above indices it was found in both the Sal forests that community species diversity and plant population density were very low. IVI value of plant community in the BNP range of Sal forest ranged from 121.584 to 0.596. Based on IVI value *Shorea robusta* (121.584), *Ageratum conyzoides* (23.02), *Clerodendrum squamatum* (19.87), *Randia dumetorum* (13.74), *Aphanamixis polystachya* (11.87), *Glycosmis pentaphyla* (11.03), *Butea monosperma* (7.29) and *Phyllanthus emblica* (5.75) were the dominant species in this Sal forest. Five species possess the IVI value less than one, indicating these are in endangered condition. IVI of plant community in the Madhupur Sal forest area ranged from 93.336 to 0.246. Based on IVI value *Shorea robusta* (93.34), *Ageratum conyzoides* (32.31), *Mallotus philippensis* (21.45), *Clerodendrum squamatum* (17.53), *Randia dumetorum* (16.19), *Aphanamixis polystachya* (13.18), *Glycosmis pentaphyla* (11.93), *Calotropis procera* (9.13), *Phyllanthus reticulatus* (7.78), *Dillenia pentagyna* (6.01) and *Paederia foetida* (4.36) were the most dominant plant species in this forest. More than 14 species possess the IVI value less than 0.5, indicating these are in endangered condition. According to the opinion of the local people, Sal forest is severely degraded, deforested and encroached. They opined only 16.09 and 19.37% area of BNP and MNP ranges of Sal forest is vegetation covered and rest part is encroached. Respondents are also noticed the species diversity also severely reduced in Bhawal and Madhupur Sal forest. Fourteen causes are identified which are responsible for encroachment and deforestation of which setting up of industries, monoculture of exotic tree species, cash crops cultivation, illegal felling of tree, ill motive of forest authority as well as local people are mentionable. Total 12 options were suggested for protecting Sal forest by the respondents of Bhawal and Madhupur. They essentially mentioned patriotism of local people, honesty of forest department authority, and consciousness of Government can only save the Sal forest as well as maintain an ecological balanced condition in Bangladesh.

INTRODUCTION

Bangladesh is a sub-tropical small South Asian country. The country has an area of 1,47,570 square kilometers and extends 820 kilometers north to south and 600 kilometers east to west. Roughly 80 % of the landmass is made up of fertile alluvial lowland called the Bangladesh Plain. The alluvial soils in the Bangladesh Plain are enriched with heavy silt deposits carried downstream during the rainy season. Of the total area of Bangladesh, agricultural land makes up 65% of its geographic surface, forest lands account for almost 17%, urban areas are 8%; while water and other land use account for the remaining 10% (FAO, 2007). Total forest area of Bangladesh is about 2.52 million hectares of which 1.52 million hectares are managed by the Forest Department (FD) of the country. According to Champion *et al.* (1955), the FD managed forest land divided into five categories viz. Tropical Wet Evergreen, Tropical Mixed Evergreen, Tropical Moist Deciduous, Tropical Open Deciduous, and Mangroves; while FMP (1992) classified as three spatial zones; (a) Hill forests in Chittagong hill tracts, Chittagong and Sylhet, (b) Plains inland Sal forests in central and northern zones, and (c) Swamp - Littoral Mangrove forests in delta and coastal regions. The Hill forests contribute 508991 ha (45.4%) followed by the Littoral Mangrove Forests and Coastal Afforestation extending over 489872 ha (43.7%), and Plain land Sal Forest account for the rest 121884 ha (10.9%) of the forest area (White and Ali, 1979). The Sal forest of Bangladesh is the part of tropical moist deciduous forest, locally

known as 'inland Sal forest' (Rashid *et al.*, 1996). Such forests are normally present in most of the lowlands and floodplains in the central and western parts of the country. Plain land Sal forests have been dramatically reduced in area and now exist only in a number of widely scattered and degraded patches (Ghaniet *al.*, 1990). The forests consist of patches of Sal coppice occasionally with other tree species. These forests lie in the districts of Dhaka, Tangail, Mymensingh, Rangpur, Dinajpur and Rajshahi. The district of Comilla also has a small patch of Sal Forest. The largest belt of the Sal forests lies in the districts of greater Dhaka, Mymensingh and Tangail which is known as "Madhupur Tract" is about 100 km long in north-south direction and 10-40 km wide in east-west direction (Reza *et al.*, 1992). The southern part of this tract is known in Bangla as 'BhawalGarh' and the northern part as 'MadhupurGarh'. 'Madhupur and Bhawal Garh' combinedly represents unique characteristics of Sal forest of Bangladesh which covered more than 80% area of this deciduous forest.

The official forest coverage of Bangladesh is around 17% against 25%, the general standard that a country should maintain. However, the 17% forest coverage has gone down to 7.29% (1.08 million hectares) according to an unpublished joint study by Bangladesh Space Research and Remote Sensing Organization (SPARSO) and the Department of Forest in 2007. Besides, the 7.29% coverage includes the forest of Chittagong Hill Tracts, Sal forest, mangrove forest, bamboo or mixed forest and rubber plantation. Tropical moist deciduous or plain land Sal forest is severely deforested. A large proportion of land under plain land Sal forest is under the possession of encroachers. More than half of the close (medium to good density) forests have either degraded to poor density forests (other forests) or deforested and encroached. Forest cover losses in Bangladesh remain unsurveyed or unmapped and their exact sizes and locations are not conclusively determined, except for periodic visual observations (FMP, 1992). Sal forest is the most threatened and vulnerable ecosystem of Bangladesh. Until the beginning of the 20th century, this forest existed as a continuous belt with rich floral and faunal diversity. Gradually increasing population put tremendous pressure on this ecosystem and changed the scenario. This forest at present gradually deforested and the remaining stands are of poor stocking. The massive destruction of Sal forests of Bangladesh occurred during the last 40 years. Biodiversity has declined rapidly and many species have disappeared.

The forests of Bangladesh have been under planned management for more than hundred years. During last few decades, the socio-economic conditions have minimized the utility and use of forest planning and management. The unplanned biotic pressures have far exceeded the planned conservation efforts and have shrunk, degraded and fragmented the forest resources. Forest sustainability in Bangladesh seems to be inversely related to the population density, poverty and non-empowerment of women in rural Bangladesh (Gain, 1998). The high population density, low agricultural productivity, poor human resource development, limited forest resources, and few employment opportunities outside agriculture jointly put higher demand on limited forest resources and accelerate deforestation and decline in forest health, quality and productivity. The Sal forests of Bangladesh are acutely impacted by deforestation, over-exploitation, excessive litter collection, encroachment, indiscriminate collection of economically important plant species (i.e. medicinal, fodder etc), and other forms of anthropogenic disturbances (Rashid *et al.*, 1996). About 60% area of Sal forest is highly degraded (Ghaniet *al.*, 1990). Natural Sal forests have been converted into plantation forests, rotational forests, exotic woodlands, rubber gardens, banana gardens, pineapple orchards, rice field, homesteads and other agricultural fields (Rahman, 2010). The existing forests are

decreasing at the rate of 9000 ha per year (FAO, 1999). In the present time in all categories (Hill forest, tidal forest and plain land Sal forest) of forest in Bangladesh, trees are merely present inside the forests. Actually only 6-7% area of Bangladesh forest land covered with trees or vegetation. Among the different forest types of Bangladesh plain land Sal forest almost in ruin condition (FMP, 1993). The unique characteristics of Sal forest is declining at an alarming rate as a result the remnants of Sal forest do not represent its tradition. Most of the Sal forestland has been denuded, degraded and encroached upon or taken over for commercial or industrial plantation of exotic species and agricultural use (Iftekhar and Hoque, 2005). Some part of the Sal forest also converted as rubber garden. Though Sal is the dominant species in this forest, there are countless other species of plants including medicinal, fruit trees, uncultivated vegetables, shrubs, herbs, creepers and thousands of other life forms (FAO, 2007). Once, Sal forest was the safe sanctuary for wildlife such as tiger, bear, monkey, langur, and birds but now it becomes history. The main causes of forest degradation are encroachment (Flint 1994; Capistrano and Kiker 1995; Rasheed 1995; Kamal *et al.*, 1999; Salam *et al.*, 1999; FAO 2002), illegal logging (Rasheed 1995); increased demand for fuelwood (Flint 1994; ADB 2002), monoculture of exotic tree species like *Eucalyptus*, *Acacia* etc. (Rasheed 1995), desperate cultivation of pineapple and banana (Gain, 2002), free grazing (Ahamed, 1998), ill motive of forest management authority (ADB, 2002), NGOs activities (FAO, 2002), involvement of tribal people (Salam *et al.*, 1999) and unplanned development activities or industrial activities (FAO, 2002). Forest encroachment happens by individuals, group of individuals and institutions (Hermosilla, 2000). In Bangladesh as well as other South Asian countries agriculture, population pressure, cash cropping, human settlement, pasture, road construction and shifting cultivation have been identified as the main causes of encroachment (Mather 1990; Collins *et al.*, 1991; Thapa and Weber 1995; Saxena *et al.*, 1997). Bhawal and Madhupur Sal forest area of Bangladesh gradually decreased in different rate viz. Madhupur Sal forest coverage reduced from 3,826 hectares in 1962 to 3,573 hectares in 1977, 1,801 hectares in 1997, and only 594 hectares in 2003 (Islam, 2009). All above mentioned causes are responsible for the encroachment and degradation of Bhawal and Madhupur Sal forest area of Bangladesh.

For conserving biodiversity, maintaining ecological balance, forest productivity and sound environment for human being as well as wild life forest resource conservation is essential. Madhupur Tract (Bhawal and Madhupur Garh) is the major part of plain land Sal forest of Bangladesh which is now severely degraded and encroached. Bhawal and Madhupur Sal forest plays a vital role for sound environment, biodiversity conservation, healthy economy and proper social life of Bangladesh as well as other South Asian countries. These forests provide valuable commodities such as timber, fuel wood, fruit, fodder, medicinal ingredients, industrial raw materials etc. But these Sal forests are encroaching drastically and soil fertility also severely degraded. Considering the above facts present study was undertaken in the Bhawal and Madhupur National Park of Bangladesh to shed light on following objectives: To know the encroachment status of Sal forest in Bangladesh and to identify causes of forest encroachment and document conservation strategies for natural plain land Sal forest of Bangladesh.

MATERIALS AND METHODS

Encroachment status and factors related to the encroachment process of Sal forest in Bangladesh was observed and understood in the Bhawal and Madhupur national park range of Sal forest during the period of 2009 to 2011. Madhupur Tract, the largest belt of the Sal forests

is about 100 km long in north-south direction and 10-40 km wide in east-west direction (Figure 1).

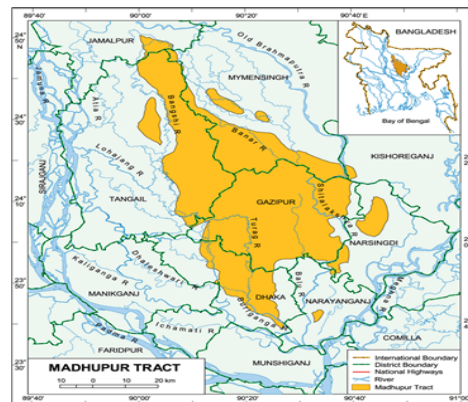


Figure 1: Study site showing Madhupur tract of Sal forest
Source: Forest Department of Bangladesh

The southern part of this tract is known as 'BhawalGarh' and the northern part as 'MadhupurGarh'. 'BhawalGarh' Sal forest is divided into six different ranges viz. Bhawal National Park Range, Bhawal Range, Rajendrapur Range, Sripur Range, Kaliakoir Range and Kachighata range. 'MadhupurGarh' Sal forest is divided into four different ranges viz. Madhupur National Park Range, Madhupur range, Dokhola range, Aronkhola range. 'Bhawal National Park Range' (Figure 2) of 'BhawalGarh' and 'Madhupur National Park Range' (Figure 3) of 'MadhupurGarh' is the study area of this research.

Bhawal National Park (BNP), about 40 km North of Dhaka, located at approximately 23°58' to 24°03' N longitude and 90°17' to 90°22' E latitude (Figure 2) besides the National Highway of Dhaka-Mymensingh, having an area of 12436 ha. BNP range divided into three small units as 'Beat' and these are Bankharia beat, Baupara beat and park beat. In this range 'Bhawal national Park' was established on May 11, 1982 with an area of 5022 ha. The soil is rich in organic matter content (0.72 – 2.45%) and this range belongs to 28th AEZ of Bangladesh (Anonymous, 2001).

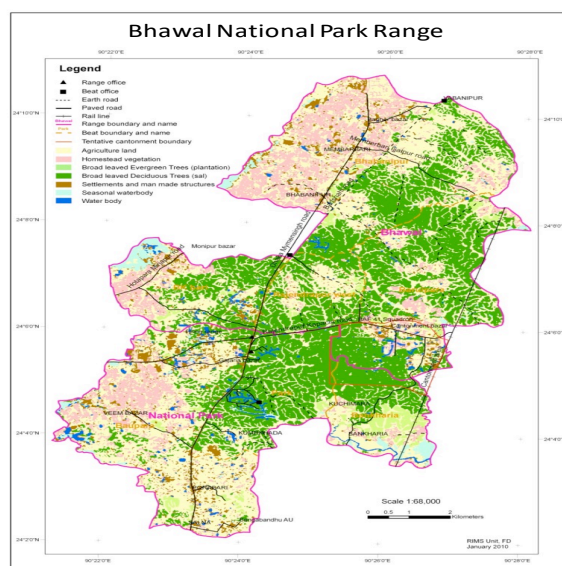


Figure 2: Bhawal National Park range of Sal forest, Bangladesh
Source: Forest Department of Bangladesh

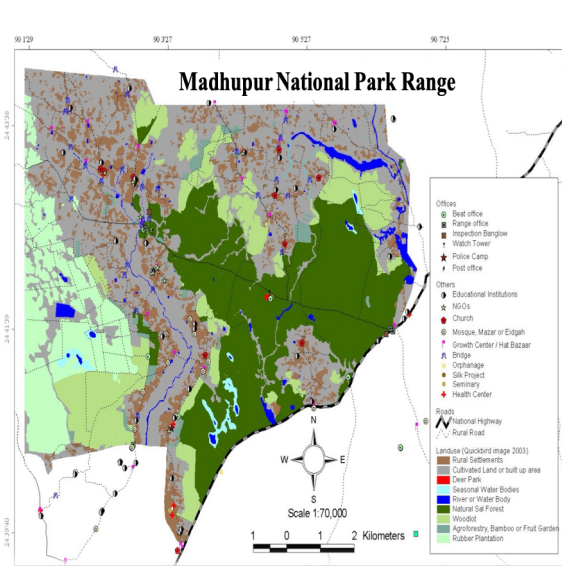


Figure 3: Madhupur National Park range of Sal forest, Bangladesh
Source: Forest Department of Bangladesh

Data were collected from both study area by using structured questionnaire. Based on the literature review, the questionnaire was carefully designed in such a way that all the agents associated with encroachment and causes of encroachment process of Sal forest were included. The draft questionnaire was pre-tested by interviewing some sample farmers of the each forest beat of both forest range by the researcher himself. Thus, some parts of the draft questionnaire were improved, rearranged and modified in the light of the actual and practical experiences gained by the researcher from the pre-testing. Finally corrected questionnaire was used for collecting information from forest area. Data were collected from 100 respondents from each forest range maintaining at least 20 respondents from each forest beat. Data were collected through several field visits in the study area and personal interviewing with the respondents. Interviews were normally conducted in farmers' house in their leisure time and even in the field when they worked in the plots. They provided information from their memory.

Respondents' characteristics and factors affecting the encroachment process represent the independent variable in this study. Thus, a total of 16 variables namely age, education, family size, occupation, role of political person, attachment of tribal people with Sal forest, role of local people, role of muscle men, role of Government, NGOs activities, development of industry inside the forest, social forestry activities, agroforestry activities, poverty and population, soil management and patriotism of the community. Encroachment status was treated as dependent variable of the study. Data were coded, compiled, tabulated and analyzed in accordance with the objectives of the study. In this process, all the respondents in the interview schedule were given numerical coded values. Local units were converted into standard units and qualitative data were converted into quantitative ones by means of suitable scoring whenever necessary. For describing the different characteristics and factors affecting the encroachment process, the respondents were classified into several categories. These categories were developed by considering the nature of distribution of data, general understanding prevailing in the social

system and possible score system. Pearson's product moment Co-efficient of correlation was used to explore the relationship between the concerned variables.

RESULTS AND DISCUSSION

Socioeconomic condition of the respondents in Sal forest areas of Bangladesh: Average age of the respondents in Bhawal and Madhupur Sal forest region were 41.08 and 46.32 years with the standard deviation of 8.33 and 7.4, respectively (Table 1). Majority of the respondent (58%) in:

Table 1. Distribution of the respondents according to their selected socio-economic characteristics (n=100)

Characteristics (Scoring system)	Categories	Percent (%)		Mean		SD	
		Bhawal	Madhupur	Bhawal	Madhupur	Bhawal	Madhupur
Age (Actual years)	Young aged (<35)	31	45	41.08	46.32	8.33	7.4
	Middle Aged (36-50)	58	39				
	Old (>50)	11	16				
Occupation	Agriculture	31	48	1.92	2.55	0.77	0.95
	Labourer	17	42				
	Service	49	7				
	Others	3	3				
Education (Year of schooling)	No education (0)	24	28	3.67	6.33	4.54	2.31
	Can sign only (0-5)	30	25				
	Primary (1-5)	19	17				
	Secondary (6-10)	15	18				
	Higher secondary (11-12)	6	8				
	Graduation (>12)	6	4				
Annual Income ('000'BDT)	Low income	84	66	99.30	80.0	6.8	2.42
	Medium income (75-150)	13	30				
	High income	3	4				
Family size (No. of family members)	Small family (up to 4)	49	65	4.82	4.51	1.5	1.6
	Medium family	40	27				
	Large family (>6)	11	8				
Farm size (ha)	Landless (0.002-	10	10	1.06	1.16	1.04	1.02
	Marginal (0.021-	6	15				
	Small (0.21-0.99)	52	43				
	Medium (1.0-3.0)	25	28				
	Large (>3.0)	7	4				

SD= Standard Deviation

Bhawal were medium aged while in Madhupur, majority of respondents (45%) were in young aged category (Table 1). Peoples of both forest areas were engaged in different occupations like agriculture, labour, service and others. Highest 49% respondents of Bhawal Sal forest region were engaged in service while in Madhupur, majority (48%) of the respondents were involved

with agriculture (Table 1). Education level was also different in both Sal forest areas. More than 50% respondents of Bhawal and Madhupur Sal forest region had no education or can sign only. Near 30% respondents of both areas of Sal forest have SSC level education or more and rests were found in primary level (Table 1). In general, the economic status of the respondents was not well as the annual income of majority peoples of Bhawal (84%) and Madhupur (66%) possessed below Tk. 75000/-. A few respondents of Bhawal (3%) and Madhupur (4%) had more than Tk. 150000/- annual income (Table 1). Average family size of the respondents in Bhawal and Madhupur Sal forest region were 4.82 and 4.51 with the standard deviation of 1.5 and 1.6, respectively. Farm size is categorized as landless, marginal, small, medium and large. Most of the respondents of Bhawal (52%) and Madhupur (40%) have small sized farm (Table 1).

SITUATION OF SAL FOREST IN BANGLADESH

To know the present situation of Sal forest in Bangladesh data were collected about the vegetation coverage, species diversity or number of plant species, medicinal plant species, number of fauna species, and attachment of tribal people with Sal forest as at present condition as well as 10 years ago. According to respondents' opinion vegetation covered area was little bit higher in Madhupur region compared to Bhawal at present time as well as 10 years ago. 10 years before overall vegetation coverage was 34.05% and 38.1% in Bhawal and Madhupur Sal forest region with the standard deviation of 3.17 and 3.8 respectively. At present, the average area under vegetation in Bhawal and Madhupur Sal forest region are 16.09% and 19.37% with standard deviation of 2.37 and 1.92 respectively. Almost 50% vegetation coverage reduced in the period 10 years duration (Table 2 and Figure 4).



Figure 4: Gradually encroachment process of Sal forest (A) Sal tree dominant in a diversify condition (B) Density and diversity become low (C) 'Chala' or high land severely eroded or encroached and (D) Sal forest look like rice field

The respondents have reported that, 10 years back the numbers of plant species in Bhawal and Madhupur Sal forest were higher than the present time. The average number of plant species was 92.11 and 192.5 in Bhawal and Madhupur Sal forest whereas after 10 years these values are 52.69 and 85.6 respectively (Table 2).

Table 2: Situation of Sal forest in Bhawal and Madhupur area of Bangladesh

Categories	Percent (%)		Mean		SD	
	Bhawal	Madhupur	Bhawal	Madhupur	Bhawal	Madhupur
Area under vegetation (10 years ago)						
Low (<20%)	25	15	34.5	38.1	3.17	3.8
Medium (20%-45%)	49	56				
High (>30%)	26	29				
Area under vegetation (at present)						
Low (<10%)	40	30	16.09	19.37	2.37	1.92
Medium (10%-45%)	45	40				
High (>15%)	15	30				
Number of plant species in Sal forest (10 years ago)						
Low (<80)	44	25	92.11	192.5	12.63	23.38
Medium (80-100)	35	30				
High (>100)	21	45				
Number of plant species in Sal forest (at present)						
Low (<50)	36	25	52.69	85.6	12.49	14.7
Medium (50-60)	36	40				
High (>60)	28	35				
Richness of medicinal plant species in Sal forest (10 years ago)						
Low (<60)	16	6	57.1	71.25	8.82	10.73
Medium (60-70)	45	76				
High (>70)	39	18				
Richness of medicinal plant species in Sal forest (at present)						
Low (<6)	45	41	7.8	11.0	4.8	8.45
Medium (6-10)	33	32				
High (>10)	22	27				
Number of fauna species in Sal forest (10 years ago)						
Low (<20)	25	23	41.6	44.5	2.6	3.1
Medium (20-40)	53	56				
High (>40)	22	21				
Number of fauna species in Sal forest (at present)						
Low (<15)	37	43	22.6	24.5	1.8	2.3
Medium (15-25)	43	40				

High (>25)	20	17				
Attachment of tribal people with Sal forest (10 years ago)						
Low (<40%)	48	30	43.78	51.67	12.91	16.98
Medium (40-50%)	35	35				
High (>50%)	17	35				
Attachment of tribal people with Sal forest (at present)						
Low (<15%)	58	40	15.71	20.6	1.51	1.87
Medium (15-30%)	22	30				
High (>30%)	20	30				

Majority of the respondents opined that diversity of medicinal plants species also decreased severely over time in the Sal forest area of Bangladesh. Like flora species fauna species also gradually decreased over time. The life cycles of tribal people were much close to Sal forest now decreasing the attachment of tribal people with this forest based on the respondents statements, it was found that at present only 15.71% and 20.6% tribal people lives near Sal forest in Bhawal and Madhupur region whereas this was 43.78% and 51.69%, respectively, 10 years back (Table 2).

ENCROACHMENT AGENTS IN SAL FOREST OF BANGLADESH

Results revealed that different agents are responsible for destroying as well as encroachment of both Bhawal and Madhupur Sal forest areas. During answering relevant open questions in the interview process, the respondents identified that local people, NGOs, local Government and forest department, political persons or muscle men are the agents of Sal forest encroachment (Table 3). Majority of the respondents opined that political persons or so called muscle men are responsible for Sal forest encroachment in Bhawal (31.3%) and Madhupur (40.4%) followed by local people (29.65 and 32.56%), local Govt. and forest department (20.39 and 16.14%), NGOs (9.45 and 10.3%) and others (10% and 5%) respectively.

CAUSES OF SAL FOREST ENCROACHMENT

In the study area, 14 causes were identified for Sal forest encroachment. These are unplanned development of industry, muscle men aggressiveness, negligence of the forest department staff, weak or inappropriate forest regulation act by the government, less patriotism of the community, bricks industry outside the forest, saw mill outside the forest, lack of education, poverty in the locality, high population, NGOs activities and wood lot garden or social forestry programme (Table 3 and Figure 5).

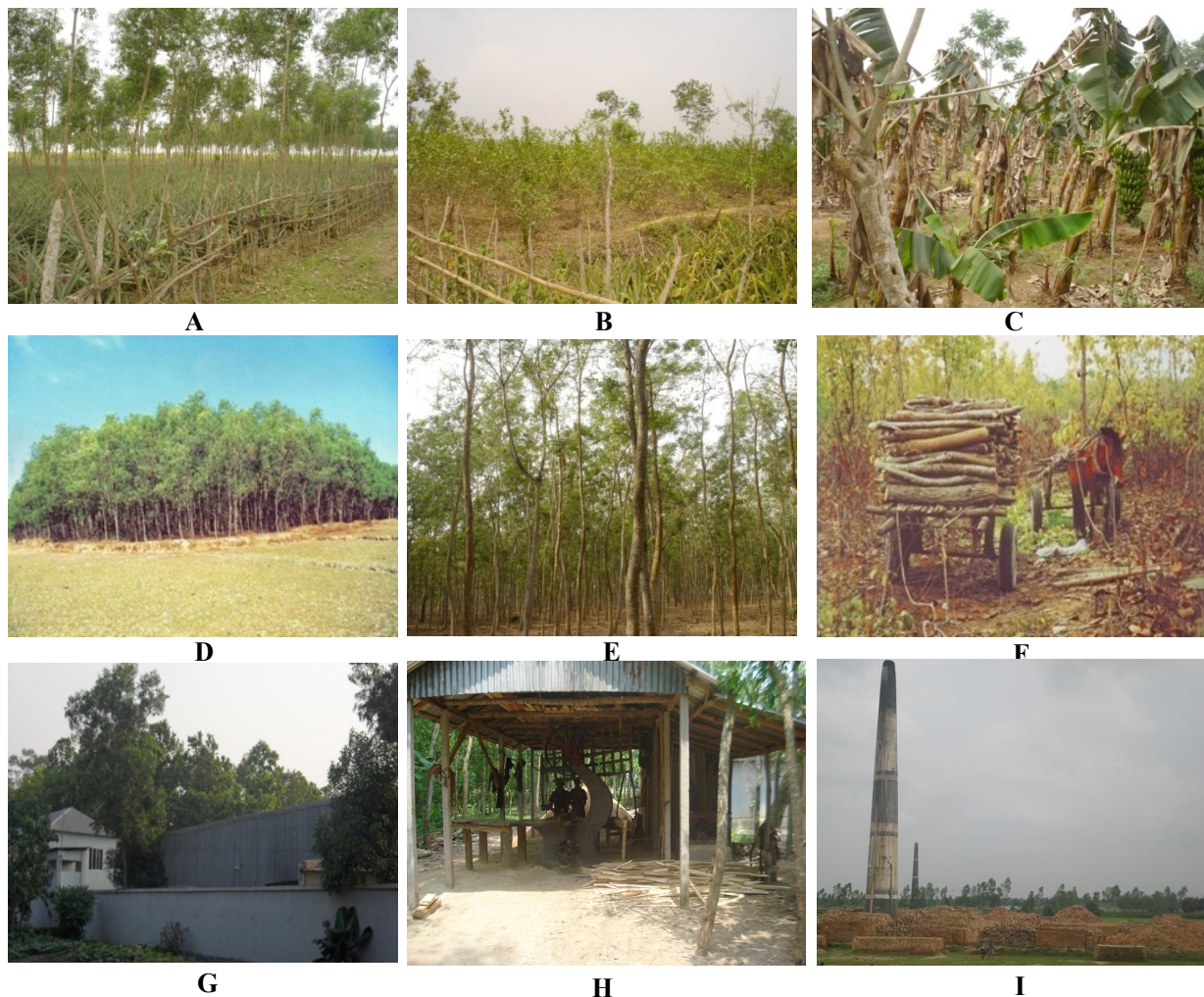


Figure 5: Causes of Sal forest encroachment: (A) Pineapple cultivation (B) Lemon cultivation (C) Desperate banana cultivation (D) Monoculture of exotic species (E) Social forestry or NGOs activities (F) Illegal tree felling (G) Industry inside the Sal forest (H) Saw mills inside the Sal forest and (I) Brick-field inside the Sal forest

Among the identified causes, majority of the respondents (19%) of Bhawal region opined that unplanned development of industry inside the forest is the dominant cause for Sal forest encroachment. Majority of the respondents (22%) of Madhupur Sal forest region stated that muscle man aggressiveness is the dominant cause of encroachment. Respondents of both Bhawal and Madhupur regions strongly opined that muscle men aggressiveness, cash crops cultivation, monoculture of exotic tree species, negligence of the forest department staff and unplanned development of industry are the major causes of Sal forest destroying.

Table 3: Encroachment agents of Sal forest in Bhawal and Madhupur area of Bangladesh

Categories	Percent (%)		Mean		SD	
	Bhawal	Madhupur	Bhawal	Madhupur	Bhawal	Madhupur
Destroying agents						
Local people	28	30	-	-	-	-
NGOs	10	10	-	-	-	-
Local Government and FD	20	15	-	-	-	-
Political persons	32	40	-	-	-	-
Others	10	5	-	-	-	-
Sal forest destroyed by local people						
Low (<20)	26	25	29.65	32.56	6.86	4.74
Medium (20-25)	45	42				
High (>25)	29	33				
Sal forest destroyed by NGOs						
Low(<10)	37	25	9.45	10.30	2.47	3.70
Medium (10-15)	36	45				
High (>15)	27	30				
Sal forest destroyed by Local Government and FD						
Low(10-20)	16	40	20.39	16.14	3.52	2.98
Medium (21-40)	44	50				
High (>40)	40	10				
Sal forest destroyed by political person and muscle men						
Low(<15)	25	10	31.30	40.45	3.71	3.98
Medium (15-30)	30	29				
High (>30)	45	61				

NGOs= Non-Government Organizations FD= Forest Department

Results of correlation test

The coefficient of correlation (r) was used to test the null hypothesis regarding the relationship between two concerned issues and results of the correlation test is presented in Table 4.

Table 4: Correlation between Sal forest encroachment and individual characteristics in Bhawal and Madhupur area of Sal forest

Individual characteristics	R values	
	Bhawal	Madhupur
Age	-0.0089	-0.0123
Education	0.2247**	0.1342*
Family size	0.2431**	0.1583**
Occupation	0.1712**	0.1841**
Role of political person	0.1193*	0.0171*
Attachment of tribal people with Sal forest	0.1025*	0.0879*
Role of local people	0.0926*	0.1194*
Role of muscle men	0.0161*	0.0775*
Role of government	0.1919**	0.2108**
NGOs activities	-0.0063	0.2176**
Creation of industry inside the forest	0.1998**	-0.1601
Social forestry activities	-0.0142	-0.0249
Agroforestry activities	-0.0162	-0.0184
Poverty and population	0.1817**	0.2081*
Soil management	-0.2001	0.2142**
Patriotism of the community	0.1163*	0.1931**

**** Correlation is significant at 0.01 level (2-tailed)*Correlation is significant at 0.05 level (2-tailed)**

Pearson's Product Moment Correlation Co-efficient (r) was used to test the null hypothesis concerning relationships between any two variables. Sixteen variables were identified to investigate the relationship between Sal forest encroachment and individual characteristics in Bhawal and Madhupur area of Sal forest. In case of Bhawal area of Sal forest, the characteristics namely education, family size, occupation, role of political person, attachment of tribal people with Sal forest, role of local people, role of muscle men, role of government, creation of industry inside the forest, poverty and population and patriotism of the community showed significant relationship with Sal forest encroachment. In case of Madhupur area of Sal forest, the characteristics namely education, family size, occupation, role of political person, attachment of tribal people with Sal forest, role of local people, role of muscle men, role of government, NGOs activities, poverty and population, soil management and patriotism of the community showed significant relationship with Sal forest encroachment. Study findings revealed that the respondents in the study area varied with age, education occupation, annual income, farm size and family size (Table 1). Family size, farm size, education and annual income of the respondents of Bhawal and Madhupur Sal forest region were almost similar. But variation was found in case of age and occupation. Majority respondents of Bhawal region involved with services whereas in Madhupur they engaged with forest activities as cash crops cultivation of social forestry activities. This indicates encroachment pattern of these areas are not same. In Bhawal areas may be industrial activities and in Madhupur cash crops cultivation and social forestry activities are responsible for encroachment. From economic and ecological aspect Sal forest of Bangladesh plays a vital role for supplying timber, fuelwood, fruits, medicinal ingredients, industrial raw materials, green vegetation, and aesthetic purpose as recreational place. But the present condition of Sal forest is not so good. From this study it was found that vegetation coverage, number plant species, richness of medicinal plants, number of fauna

species and attachment of tribal people with forestry activities were severely reduced compared with 10 years previous condition as well as original condition (Table 2). Similar message also noticed by different researchers (Gain 2002; Mondolet *et al.*, 2010). Encroachment status in Bhawal and Madhupur is not similar, in Bhawal the condition is more severe compared to Madhupur. Due to desperate industrial development inside the forest area may the major cause for this situation whereas in Madhupur, encroachment process is little bit slower than Bhawal region. Respondents of Madhupur region opined that cash crop (banana, pineapple, papaya, lemon) cultivation is the major cause for encroachment (Figure 5) and that's why encroachment process in this region is comparatively slower than Bhawal region.

Bangladesh is amazingly green but at the same time it is a forest poor country (Gain, 2006). Once this statement was wrong and it was as "Bangladesh is an evergreen country with biodiversity rich green forest". Encroachment of protective area is a common phenomenon in Bangladesh as supported by Nath and Alauddin (2006) and Okaka (2007). Different agents are responsible for this alarming situation and present study identified these agents based on respondents' opinion (Table 3). These agents are destroying Sal forests through different activities which are the causes of Sal forest encroachment in Bangladesh (Table 5). Among the different causes, unplanned establishment of industry inside the Sal forest, ill motive of political person, forest department authority and local people, cash crops cultivation, monoculture of exotic trees, illegal tree felling are mentionable (Figure 5). This study also found significant positive relationship between Sal forest encroachment and above mentioned causes. Due to these reason some parts of Sal forest in Bangladesh already in ruin condition and others also verse of ruination. Hence, it is the time to take initiative for increasing the species richness in the view of reducing the Sal forest encroachment. Several national and international researchers studied on the Sal forest and they focused the necessity of this forest conservation (Hales, 1989; Sekhar, 2003; Walpole *et al.*, 2001; He *et al.*, 2008). This study identifies different causes which are responsible for deforestation and encroachment of Sal forest. Most of the causes are man-made which can reduce by different initiatives (Table 5). Majority of the respondents in Bhawal and Madhupur region of Sal forest stated that patriotism of local people, honesty of forest department authority, consciousness of Government can effectively reduced the encroachment of Sal forest in Bangladesh.

Table 5: Probable reasons for forest encroachment in Bhawal and Madhupur area of Sal forest

Reasons	Percent (%) of respondents		Rank order	
	Bhawal	Madhupur	Bhawal	Madhupur
Unplanned development of industry	19	0	1	9
Muscle men aggressiveness	18	22	2	1
Negligence of forest department staff	11	11	3	3
Forest regulation act by the government	8	5	5	6
Lack of patriotism of the community	5	7	7	5
Bricks industry outside the forest	5	4	7	7
Saw mill outside the forest	4	3	8	8
Lack of education	4	5	8	6
Poverty in the locality	4	5	8	6
High population	3	8	9	4
NGOs activities	1	2	11	9
Social forestry programme	2	2	10	9
Cash crops cultivation	10	18	4	2
Monoculture of exotic species	6	8	6	4

Sal forest is the only plain land forest in Bangladesh but this forest is severely encroached by different reasons. Hence its management is necessary. Encroachment of Sal forest can be minimized, if the government is conscious, forest department stuffs are responsible, local peoples are conscious and patriotic and political persons are realistic. Some management option or measurements against encroachment were listed based on respondents opinion.

Table 6: Probable solutions against encroachment of Sal forest

Solutions	Percent (%) of respondents		Rank order	
	Bhawal	Madhupur	Bhawal	Madhupur
No Industry inside or outside the forest	16	9	1	4
Strong forest regulation act	9	10	3	3
Responsible employee of the forest department	10	16	2	1
Knowledge of local people about forest management	8	10	4	3
Bricks industry should be removed from the forest	10	2	2	7
Saw mill should be removed from the forest	7	2	5	7
Creating alternate income source rather than forest	10	12	2	2
Sound political attitude	9	16	3	1
Proper health care facilities and communication system	3	3	8	6
Proper soil management	4	5	7	5
Strong government support	8	14	4	2
Patriotism of the local community	6	10	6	3

Total twelve options were suggested by respondents of Bhawal and Madhupur and these are: No industry inside or outside the forest, strong forest regulation act, responsible employee of the forest department, education about forest in local people, bricks industry should be removed from the forest, saw mill should be removed from the forest, creating alternate income source rather than forest, sound political attitude, proper health care facilities and communication system, proper soil management, strong government support, and patriotism of the local community. Respondents of Bhawal Sal forest region are discourage industry inside the forest as first priority and in Madhupur region responsibilities of Government and forest department stuffs were rank as first priority.

CONCLUSIONS

Present study estimates the correlation between dependent and independent variables separately for Bhawal and Madhupur Sal forest regions. Dependent variable was Sal forest encroachment and independent variables were age, education, family size and occupation of the respondents, role of political person, attachment of tribal people with Sal forest, role of local people, role of Mussels men, role of Government, NGOs activities, development of industry inside the forest, social forestry activities, agroforestry activities, poverty and population, soil management and patriotism of the community. In Bhawal region, education, family size and occupation of the respondents, role of political person, attachment of tribal people with Sal forest, role of local people, role of muscle men, role of Government, creation of industry inside the forest, poverty and population and patriotism of the community were significantly correlated with Sal forest encroachment. In the Madhupur region, education, family size and occupation of the respondents, role of political person, attachment of tribal people with Sal forest, role of local people, role of Mussels men, role of Government, NGOs activities, poverty and population, soil management and patriotism of the community had significant positive correlation with the Sal forest encroachment. Total area of plain Sal forest was 121, 884 ha and which was the 10.9% area of total forest in Bangladesh. This natural Sal forest has some unique characteristics with biodiversity rich ecosystem. But, today the remnants of the Sal forest are not representative of the traditional Sal forest. Present study observed encroachment status of Sal forest in Bangladesh. The natural Sal forest is now severely encroached, degraded and deforested. The vegetation coverage of this forest is drastically reduced from its original existence. According to the opinion of local people, Sal forest lost more than 50% area from Bhawal and Madhupur regions. They also opined that species diversity and plant density were reduced at an alarming rate. Many causes are found responsible for Sal forest encroachment. Among these setting up of industries, monoculture of exotic tree species, cash crops cultivation, illegal felling of tree, ill motive of forest authority as well as local people are the major causes for encroachment, degradation and deforestation. From this study it is concluded that conservation of Sal forest is obligatory for economic as well as ecological aspects. Patriotism of local people, honesty of forest department authority, and consciousness of Government can effectively reduce the encroachment of Sal forest in Bangladesh, and it is essential for maintaining ecological balance. Considering the present study some recommendations regarding Sal forest conservation are: Forest department needs to arrange more seminar, symposium, meeting etc. with local people regarding the importance of Sal forest, need to follow the tree felling rule which was prescribed by the Forest Department of Bangladesh, need to remove industrial activities from the Sal forest region of Bangladesh, need to create alternative income source rather than forest, need to convince the people to adopt social forestry and agroforestry activities in the deforested areas of Sal forest, need to rehabilitate the

local people who live inside the Sal forest to other places for recovering the lost forest area and honesty of forest department authority and consciousness of Government can effectively reduce the encroachment.

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