Forest Cover Change Analysis Using Remote Sensing Techniques in Madhupur Sal Forest of Bangladesh

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Abstract

Deforestation, degradation, damages, transformation and over exploitation of forests are the common problem in different parts of the world. Timely monitoring and assessment of forest resources may help to address and identify the above mentioned problems and thus proper guidance may be given the forest resources manager for rational planning and management of forests. Apart from the conventional methods of forest monitoring, remote sensing with its unique capability of synoptic viewing, real time and repetitive nature offers a potential tool for monitoring and evaluation of forest resources and hence remote sensing technology has been successfully used in various studies like forest inventory, monitoring of forest cover changes and forest damage assessment. In the present research forest cover change analysis in ôMadhupur Sal Forestô located in central part of Bangladesh has been investigated using satellite remote sensing data and spatial analysis. Transformation of ôSal forestô to other landuse has been studied using the Landsat MSS (Multi Spectral Scanner) data of 1973 and Landsat 8 OLI (Operational Land Imager) data of 2015. Driving forces behind the transformation of ôSal forestô has also been investigated through GPS (Global Positioning System) based ground verification and interview with the people living in the locality.

Keywords: Forest transformation, Landsat MSS/OLI, Madhupur Sal forest, Remote sensing

Introduction

Forest is an important component of ecosystem which is bearing the flora and fauna. Forest plays significant roles for maintaining the equilibrium in the environmental and ecological processes. Ever-increasing human population over the country with limited natural resources exerts continuous threat to the environment in which they are living.

Bangladesh is a relatively smaller country in South-east Asia with a significantly high rate of population growth. The land area is fixed here but it is continuously acquiring the over burden of population density approximately 1000 per square kilometer. As a result the land physical characteristics are under over stressed condition and the landscapes are being changed rapidly. Fragmentation of land is going on in a very dynamic way and thus the agricultural and mainly the forestry land is shrinking regularly. The same trend is also imposing on low land and shallow water bodies especially nearer to the urban and semi urban area. More significantly in the perspective of Bangladesh, such adverse effects of land cover change and deforestation are much more pronounced.

The area of global forest cover is just over 4 billion hectares, 31% of total land area (FAO, 2010) and the total carbon storage of global forest ecosystem is estimated to be 638 Gt for 2005, which is more than the amount of carbon in the entire atmosphere (FAO, 2005). The rate of carbon accumulation and release of a forest ecosystem due to forest growth and deforestation activities play a role in terrestrial carbon flux.

Land use land cover changes analysis is an important tool to assess global change at various spatial-temporal scales. It also reflects the dimension of human activities on a given environment (Lopez *et al*. 2001 in Dewan and Yamaguchi, 2008). Remotely sensed data may be particularly useful in developing countries where recent and reliable spatial information is lacking (Dong *et al.,* 1997) reported by Dewan and Yamaguchi (2007).

Remote sensing with its unique capability of synoptic viewing, real time and repetitive nature offers a potential tool for monitoring and evaluation of Earthôs natural resources. Perhaps, forestry is one of the most important disciplines in which remote sensing technology is being used over a considerably long time period from the early stage of its development. Remote sensing technology has been successfully employed in various studies like forest inventory, monitoring of forest cover changes, forest damage assessment etc.

Therefore the present study has been undertaken to investigate the transformation of Sal forest to other landuses and seasonal behavior of Sal forest canopy in Madhupur Sal forest. A combined remote sensing and GIS approach has been adopted for the present study.

Study area

The study area is located in Madhupur Sal forest region that is situated in Tangail and Mymensingh district. Figure 1 shows the study area. The area extends from N 24° 32' 44" to N 24° 44' 42.7" and E 89° 59' 49.5" to E 90° 10' 34.6" and is and is about 120 km away from the capital city of Dhaka. Relatively high land in one part and lowland areas in adjacent part characterize landscape of the area. The area is fragmented into small patches and intermingled with the neighboring settlements. The forest of the study area is classified as tropical moist deciduous forest

(Champion et al. 1965). Sal (*Shorearobusta*) is the main species in the natural forest. The climate of this area is tropical. The average rainfall of this is about 205 cm. Average temperature gradually rises from February and reaches to its maximum in April (around 35ŰC). In January minimum temperature is recorded 15ŰC.

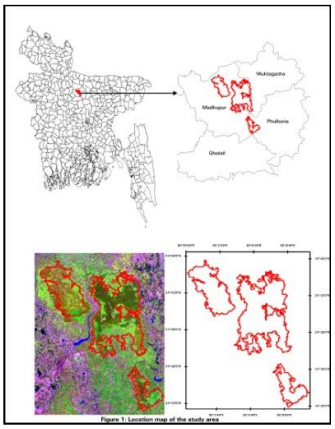

Fig. 1: Location map of the study area.

Data and Software Used

Landsat MSS data has been collected from SPARRSO archive. Geometric distortion has been checked and image-to-image geometric correction has been performed. Landsat MSS observation of Madhupur Sal Forest and its adjacent areas Band 4, 2 and 1(R, G, B) and Band 2, 4 and 1 (R, G, B) in 21 February, 1973 have been shown in figure 2 and 3 respectively.

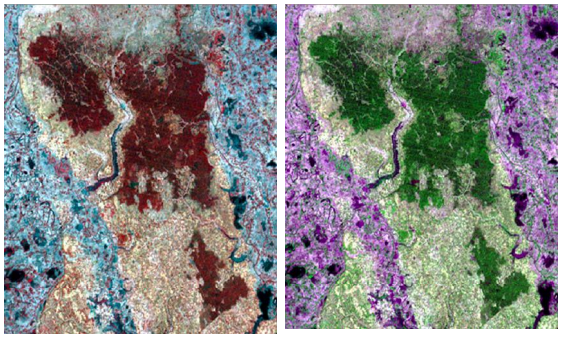

Figure 2 & 3. Landsat MSS observation of Modhupur Sal Forest and Its Adjacent Areas Band 4, 2 and 1 (R, G, B) & Band 2, 4 and 1 (R, G, B) in 21 February, 1973.

Cloud-free Landsat data over the dry period (September-March) have been downloaded form United States Geological Survey (USGS) website. Extraction of different bands data has been done and then layer stacking of has been conducted for making the multi bands images. Landsat 8 OLI observations of Madhupur Sal Forest and its adjacent areas Band 5, 4 and 3 (R, G, B) and Band 6, 5 and 4 (R, G, B) in 12 November, 2015 have been shown in figure 4 and 5 respectively.

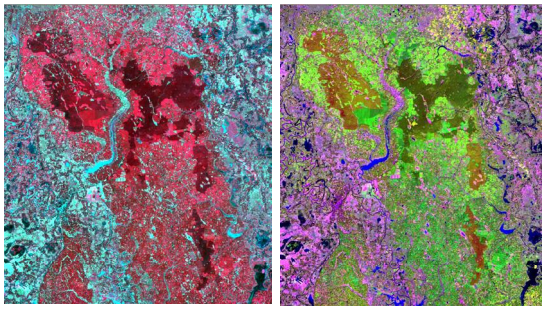

Fig. 4 & 5. Landsat 8 OLI observations of Madhupur Sal Forest and its adjacent areas Band 5, 4 and 3 (R, G, B) & Band 6, 5 and 4 (R, G, B) in 12 November, 2015.

Digital image processing (DIP) of the satellite data were carried out in ERDAS IMAGINE software. Vector layers have been prepared in Arc/Info software.

Methodology

On screen digitization has been performed to delineate the different vegetation classes. Global Positioning System (GPS) based ground verification has also been conducted in different vegetation classes to accurately delineate the appropriate vegetation type in the study area. The following methodology has been adapted for the present study. The flow chart of the methodology for the present work has been shown in figure 6.

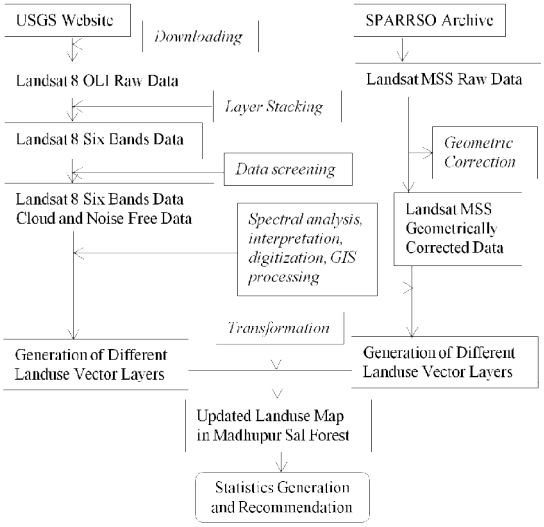

Fig.6. Shows the whole methodology of the research.

Results & Discussion

Interpretation and identification of different land use classes

The forest area is an undulating landscape and is composed of highland called óChalasô and lowland called as óBaidô. The area comprises of a number of surface classes. Figure 7 shows the colour composite of Landsat 8 OLI image of 12 November, 2015 comprising of bands 6, 5 and 4 (R, G, B) where the location of different landuse classes has been shown.

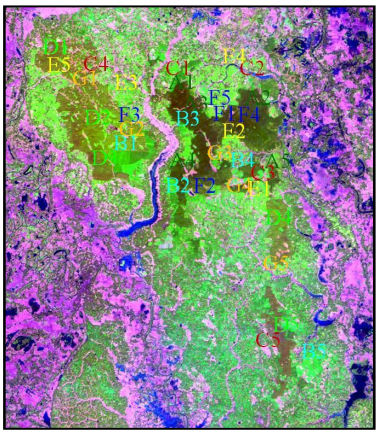

Fig. 7. Shows the colour composite of Landsat 8 OLI image of 22 November, 2015 comprising of bands 6, 5 and 4 (R, G, B) where the location of different landuse classes has been shown.

The deep green colour represents the óSal forestô area and the top dominating class (located at A1: 90° 05′ 04.65″ E 24° 42′ 37.16″ N ; A2: 90° 07′ 39.15″ E 24° 42′ 19.33″ N ; A3: 90° 05′ 36.22″ E, 24° 41′ 42.00″ N ; A4: 90° 04′ 56.07″ E 24° 40′ 06.05″ N and A5: 90° 08′ 14.82″ E 24° 39′ 58.81″ N).

The dark green colour represents the óAcacia & Pineappleô areas (located at B1: 90° 02′ 58.03″ E 24° 40′ 37.88″ N; B2: 90° 04′ 51.21″ E 24° 39′ 22.19″ N; B3: 90° 05′ 05.55″ E 24° 41′ 35.25″ N; B4: 90° 07′ 01.11″ E 24° 40′ 00.11″ N and B5: 90° 09′ 49.52 E 24° 34′ 02.12″ N).

Green and light green mixed small patched scattered surrounding the Sal dominating area represents the óMixed Vegetationô (located at C1: 90° 04′ 41.32″ E 24° 42′ 58.88″ N; C2: 90° 07′ 25.06″ E 24° 43′ 00.50″ N; C3: 90° 07′ 48.03″ E 24° 39′ 41.97″ N; C4: 90° 01′ 45.69″ E 24° 43′ 08.05″ N and C5: 90° 08′ 32.35″ E 24° 34′ 32.97″ N).

Brownish green colour represents the óRubber plantationô and it is the second dominating big patched area (located at D1: 90° 00′ 26.18″ E 24° 43′ 36.74″ N; D2: 90° 01′ 46.06″ E 24° 41′ 37.65″ N; D3: 90° 02′ 26.78″ E 24° 39′ 57.43″ N; D4: 90° 08′ 18.40″ E 24° 38′ 16.99″ N and D5: 90° 08′ 50.72″ E 24° 34′ 38.42″ N).

Light green colour moderately bigger patches are the óBanana plantationô area (located at E1: 90° 07′ 51.63″ E 24° 39′ 01.37″ N; E2: 90° 06′ 44.83″ E 24° 41′ 18.15″ N; E3: 90° 02′ 51.23″ E 24° 42′ 31.67″ N; E4: 90° 06′ 44.04″ E 24° 43′ 26.54″ N and E5: 90° 00′ 29.59″ E 24° 43′ 16.64″ N).

Blue colour is the water area and it is the lowest area than óOthersô class (located at F1: 90° 06′ 35.11″ E 24° 41′ 36.98″ N; F2: 90° 05′ 28.52″ E 24° 39′ 30.04″ N; F3: 90° 02′ 32.90″ E 24° 41′ 35.64″ N; F4: 90° 07′ 00.20″ E 24° 41′ 27.36″ N and F5: 90° 05′ 13.25″ E 24° 40′ 02.02″ N).

Light magenta colour represents the óAgricultureô area and it basically located in óBaidô area (locations are G1: 90° 00′ 53.01″ E 24° 43′ 24.24″ N; G2: 90° 03′ 05.90″ E 24° 41′ 17.01″ N; G3: 90° 06′ 12.71″ E 24° 40′ 19.01″ N; G4: 90° 07′ 33.67″ E 24° 39′ 25.63″ N and G5: 90° 08′ 32.11″ E 24° 37′ 38.07″ N).

Statistics has been generated from the analyzed images of the study area and it has been found that the Sal forest are was 9749.98 ha in 1973. Gradually Sal forest area has been transformed in to the following land use as óAcacia & pineappleô, óMixed vegetationô, óRubber plantationô, óBanana plantationô, óWaterô and óAgricultureô area. Table 1 provides a list of different land uses in two different years. Figure 8 shows óSal forestô and associated land use map in 2015.

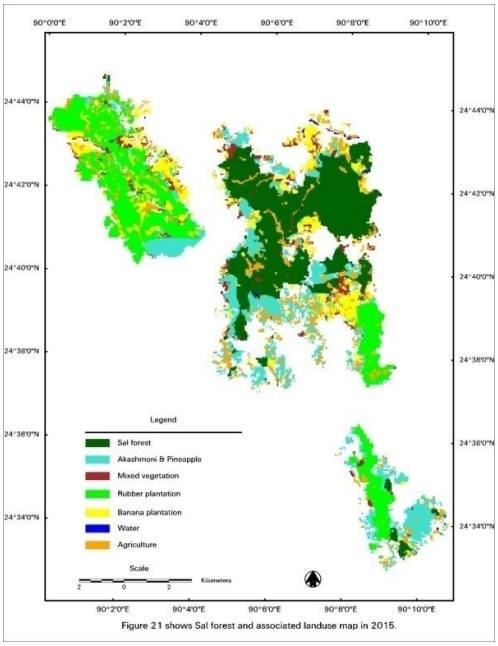

Fig. 8. Shows óSal forestô and associated land use map of Madhupur Sal Forest in 2015.

Table 2. Land use statistics in 1973 and 2015.

Year	1973		2015		% of total
Sl.	**Land use**	**Area (in ha)**	**Land use**	**Area (in ha)**	**-**
1	Sal forest	9749.98	Sal forest	2671.99	27.41
2			Acacia & Pineapple	2223.99	22.81
3			Mixed vegetation	828.05	8.49
4			Rubber plantation	2111.59	21.66
5			Banana	842.84	8.64
6			Water	28.54	0.29
7			Agriculture	1043.00	10.70
Total:		9749.98		9749.98	100

Land use transformation

Sal forest

If we look at the Sal forest area in 1973, then it has been found the whole area is located in three zones and it may be named as Zone 1 (top left), Zone 2 (top right) and Zone 3 (bottom) as shown in figure 9. In 1973 ôSal forestô area was 9749.98 ha but in 2015 only 2671.99 ha remain as ôSal forestô which is 27.41% of the total area. Zone 1 fully transformed to other landuse, very small area remain as ôSal forestô in Zone 3 and ôSal forestô remain as ôSal forestô in Zone 2 (figure 10).

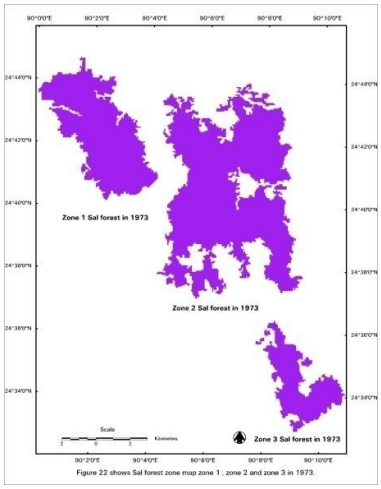

Fig. 9. ôSal forestô area in 1973 has been divided in three zones and named as Zone 1 (top left), Zone 2 (top right) and Zone 3.

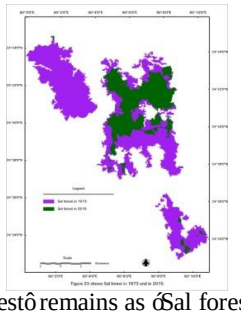

Fig. 10. ôSal forestô remains as ôSal forestô in 2015.

Acacia & Pineapple

Another transformation is ôSal forestô area to ôAcacia & Pineappleô area and here 2223.99 ha area of total ôSal forestô area transformed to ôAcacia & Pineappleô area which is 22.81% of total area. The typical characteristic of this encroachment is big patches located around the Zone 2 and bottom of Zone 1 and Zone 3 (figure 11).

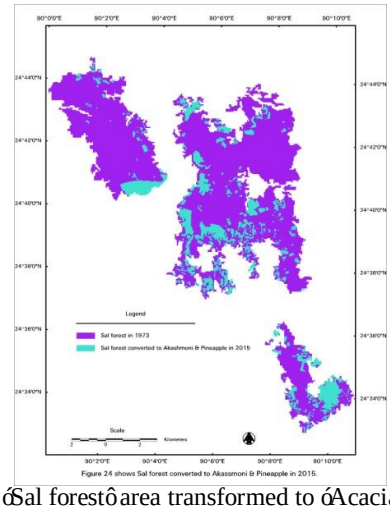

Fig. 11. ôSal forestô area transformed to ôAcacia & Pineappleô area in 2015.

Mixed vegetation

ôMixed vegetationô area is 828.05 ha which is 8.49 % of total area and located spread over mainly in the middle part of Zone 1 and Zone 2 and small portion is located in surrounded in Zone 3 (figure 12).

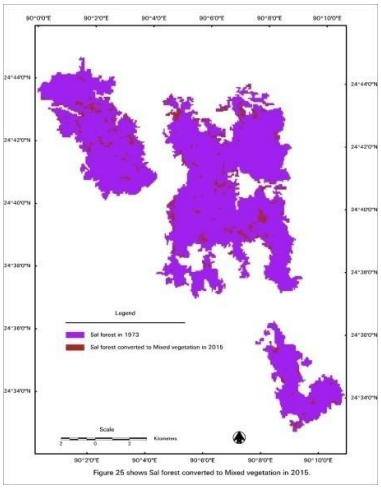

Fig. 12. ôSal forestô area transformed to ôMixed vegetationô area in 2015.

Rubber plantation

ôRubber plantationô is one of the main landuse transformations which is 2111.59 ha of total area and by percentage it is 21.66 %. All most all area of Zone 1 has been transformed to ôRubber plantationô half of the Zone 3 transformed to ôRubber plantationô and similar area of bottom right in Zone 3 has been transformed to ôRubber plantationô (figure 13). The total area of

óAcacia & Pineappleô and óRubber plantationô are very close, 22.81% and 21.66 % respectively but the nature of transformations are different from each other. There are two big patches of óAcacia & pineappleô in the bottom of Zone 1 and Zone 3 another medium size patches are located in top left, middle left and bottom of Zone 2. Moreover small patches are spread over all the three zones.

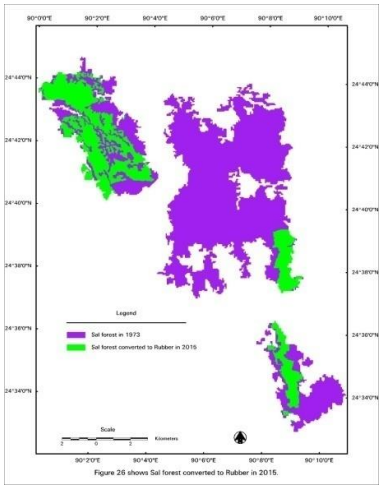

Fig. 13. óSal forestô area transformed to óRubber plantationô area in 2015.

Banana plantation

óBanana plantationô area is 842.84 ha which in 8.64 % of total area is and mainly located in Zone 1 and Zone 2 (figure 14). The total area of óBanana plantationô and óMixed vegetationô are very close, 8.64 % and 8.49 % respectively but the nature of transformations are different from each other. There are two big patches located in top left and middle right of Zone 2. Three big patches are located in top, centre middle bottom of Zone 2. Moreover small patches are spread over the Zone 1. Only a few small patches are located in Zone 3.

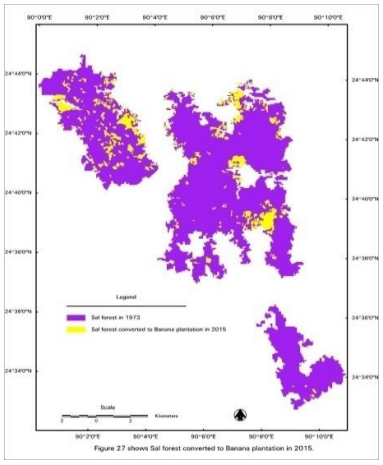

Fig. 14. óSal forestô area transformed to óBanana plantationô area in 2015.

Water area

óWaterô area is 28.54 ha which in 0.29 % of total area is and mainly located in Zone 2. A lake and some ponds are included in this class (figure 15).

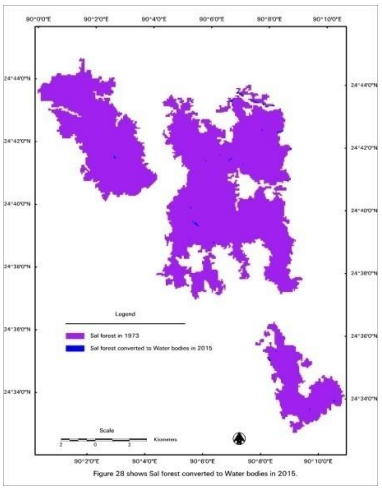

Figure 15: óSal forestô area transformed to óWaterô area in 2015.

Agriculture

óAgricultureô area is 1043.00 ha which in 10.7 % of total area is and located in spreading all the three zones. These areas are mainly located in óBaidô areas (figure 16).

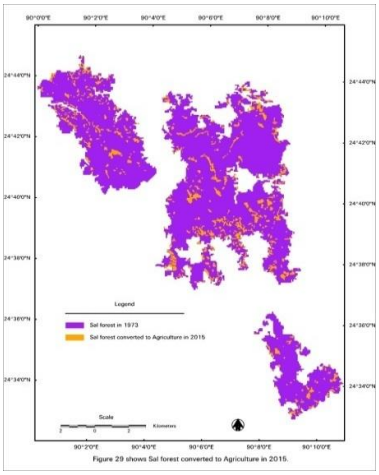

Fig. 16. óSal forestô area transformed to óAgricultureô area in 2015.

Driving factors for 'Sal forest' transformation

Illegal logging

Deforestation and encroachment has been occurred due to illegal logging. Bangladesh Forest Department is trying to protect matter but the constraint is to limited number of forest guard compare to the large area.

Twigs collection by local people
The local people in and around the forest area are collecting the twigs of ósal forestô and coppice mainly for fuel wood collection purpose. Sal is a natural forest and it is regenerated naturally from coppice. Therefore destruction of coppice enhances the degradation/depletion of Sal forest.

Cattle grazing
Human interference and grazing are the two major problems of the forest management.

Rubber plantation as a cash crop
Since 1987 some of the areas of ósal forestô had been removed and these deforested areas are planted with rubber as introduced by Bangladesh Forest Industries Development Corporation (BFIDC). The raising of rubber plantations was continued up to 1997 for 10 years. The program has been started as an experimental basis for ensuring the economic use of the forest land.

Fire in forest
Sudden forest fire occurs in the forest and it has been claimed by the forest department as throwing of smoking cigarette. But it is actually it is done intentionally as said by common mass. First the forest has been burned and later on at the deadly condition it has been cut and taken away by the people.

Agricultural practices
Depleted forest area has been converted into agricultural land and is used for seasonal crop cultivation.

New habitations
This deforested area has been used for the expansion of new habitations.

Conclusions

Deforestation is one of the major problems in the world that has serious adverse effects both on environment and ecology over a region and here the Madhupur Sal forest is also facing the same threat since several decades. The Madhupur Sal forest is facing severe threat by the disturbances caused by the people who are depend or pretend o be depended on the forest resources for their livelihood. As a consequence threats there a massive depletion various environmental and ecological problems may be provoked. The land use transformation is affecting aerial extend of Madhupur ósal forestô and quantity and quality of forest cover in the area is depleting day by day. Degradation of forest and changes in forest areas in the Madhupur forest is alarming as found through the temporal study of two tomes satellite data. Natural habitations of wild animal wild pig, monkey, deer, lizard, squirrels, python, birds are depleting as a results these are coming out from the forest to locality as stated by the people living in the locality. Due to the well connectivity with the capital Dhaka an indication building infrastructure for business has been noticed along the roads although the scale is very low but which is also alarming.

People living in and around the Madhupur Sal forest are not fully aware of the importance of the conservation measure regarding the Sal forests. Forest resources are being exploited the people according to their needs without thinking the sustainable way of uses. Building the awareness of nature conservation is required through the encouragement and involves the people living around for forest protection. Under this circumstances forest management efforts need to consider community-based forestry programmers involving local people in forest management activities for severely disturbed areas. But for less disturbed area afforestation practices could be done with the same species of itôs surrounding under the management and control of forest department. Thus the extinction of rare forest species will be controlled and the restoration of Madhupur Sal forest may be ensured for future. Necessary measures should be taken by the concern authority to protect these valuable forest flora and fauna of Madhupur ósal forestô of Bangladesh.

Acknowledgements

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