Journal of Bangladesh Institute of Planners ISSN 2075-9363
Vol. 5, December 2012, pp. 199-203, © Bangladesh Institute of Planners

Identifying the Impact of Road Networks on Forest Land Using Geographical Information System and Remote Sensing: A Case Study of Teknaf Reserved Forest

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Abstract

The aim of this study is identifying impact of road networks on forest land. Teknaf Reserved Forest area was selected for case study. To make the study forest land class was defined using remote sensing (RS) analysis. Then evaluation on changes of forest coverage was made using GIS analysis tools. The study results were validated by conducting interviews with local stakeholders. The study finds that within a reasonable visible range there is no impact of metal road on forest land, while, the impact of footpath is highest. It also shows that decreasing rate of forest land due to all type of roads is lower than that of all over the study area.

Introduction

According to Forest Department (2004), almost 17.5% (2.53 million ha) of land in Bangladesh is under forest area, while, from a source of United Nation (MDGIs), in 2000 the portion of forest area is 11.3% and in 2010 it is 11.1%. Whatever the different estimations, those figures are substantially lower than the global average which is around 31% of total land of the earth (FAO, 2010). Of the 2.53 million ha of forest land, which is officially declared, the Forest Department manages 1.53 million ha (FAO, 2006), which is treated as reserved forest area. In recent decades government is putting various efforts to the management of forest resources in Bangladesh (Hossain et al.: 29). The prime objective of those attempts is enhancing environmental preservation and conservation. To conserve, maintain and or manage the natural resources, around 10.7% of total reserved forest area, which covers 262961 ha, has been declared as "Protected Areas" under the Wildlife (Preservation) (Amendment) Act, 1974. There are 15 National Parks covering around 17% and 31 Wildlife Sanctuaries covering around 83% of total protected areas. There are other conservation sites which include Botanical Gardens, Eco-Park, Safari Park etc. (FDa; FDb).

Although government efforts toward protecting forest lands are much striking, but, deforestation is continuously taking place in almost all over the forest land of Bangladesh. Each year around 3.3% of forest land is declining ((Khan *et al*., 2004). Such degradation of forest land also exists within the protected areas. According to a report prepared by International Resources Group (IRG, 2011: vi), 4 out of 7 surveyed protected areas faced loss of forest coverage at a range of 16%-46% from 1989 to 2009, where, Teknaf Wildlife Sanctuary has highest decreasing rate.

There are many causes for deforestation. Increased population pressure, urbanization, industrialization, conversion to agricultural and other land uses, infrastructural development, natural and manmade hazards, poverty, landlessness, illegal encroachment and cutting wood etc. are some root causes for deforestation (Hossain et al.; Islam and Sato 2012: 171-178; Schaeffer et

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al. 2005: 1046-1047 and Laurance et al. 2002: 737–748). Infrastructure like road network development may have significant impact on forest land (Schaeffer et al. 2005: 1046-1047). Road network paves the way of other social, economical and physical development. Settlement patterns are guided by road network in many cases. Utility services could be transmitted through roads. So, road network is an important component in the context of urban and regional planning. (Carter 1995; Doxiadis and Constantinos 1971, ASCE 1986). Road network influence other factors like promotion of agricultural land expansion, landuse alteration, urbanization, industrialization etc. which contribute to deforestation. So, in these considerations, the aim of this research is finding impact of road networks on forest land, where, GIS and RS (Remote Sensing) technology was used to make the determinations.

Study Area

Teknaf Wildlife Sanctuary and its surrounding reserve forest area have been selected for this study. The study area is under Teknaf forest range of Cox's Bazar forest division. It is located at the southern part of the Cox's Bazar-Teknaf peninsula surrounded by Bay of Bengal in the west and Naf River in the east (Figure 1). Teknaf reserved forest supports highest biodiversity of Bangladesh. The place is habitat of 290 plant, 55 mammal, 286 bird, 13 amphibian and 56 reptile species. The major attractive animal of this forest is elephant. It is the home for one third of total elephant population of the country (Alam et al. 2010: 163-162). Total area under Teknaf forest jurisdiction is 8882.1 ha.

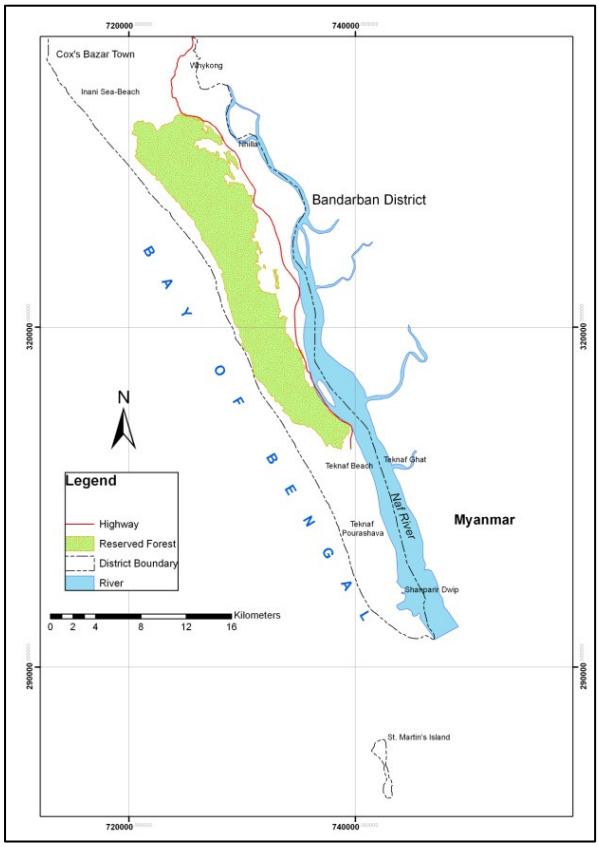

Fig. 1: Study area map

Data Collection

Two geo-referenced Landsat 5 TM satellite images were collected from Forest Department. The Landsat 5 TM imagery is acquired in seven spectral bands, where, each imagery has a 30 m ground resolution for all bands except band-6, which has a 120 m resolution. Two images were acquired in two different periods dated in 22 February 1989 and 6 December 2009 respectively. Other collected GIS and RS data were 0.6m Quickbird Satellite Image, forest jurisdiction boundaries, road network, rivers and other water bodies. All these data were also collected from Forest Department except Quickbird image. These data were used to make land cover classification in two different periods and to assess the changes in forest cover. Data to prepare study area map (Figure-1) were also collected from Local Government Engineering Department (LGED).

Ground truth GPS data were collected from field survey to support digital classification and accuracy assessment. Finally, interviews were conducted with stakeholders to validate the study result.

Image Classification

The images were classified in digital unsupervised classification method. To authenticate the classification ground truth data, Quickbird image and other ancillary data like forest boundaries, water bodies etc. were used. The major land classes were determined as forest, hurb/shrub/bushes, water bodies, agricultural and barren lands; and settlements. Later, only forest class was used for analysis (Figure 2 and 3). The classification techniques were accomplished in ArcGIS 9.3 software.

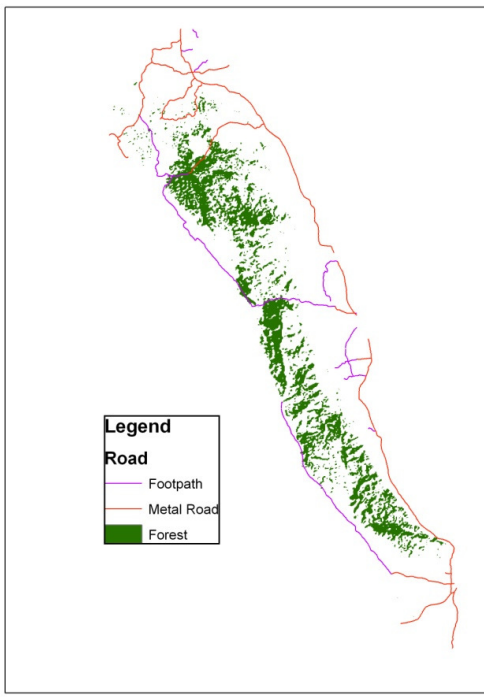

Fig. 2: Forest cover in 1989.

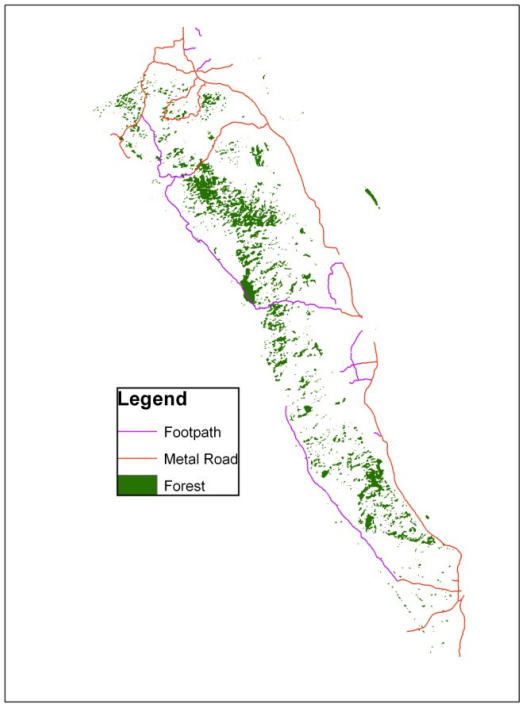

Fig. 3: Forest cover in 2009.

Data Analysis

Using the classified images, the changes in forest cover for all over the area was calculated. A buffer of 0.75 km was created for both metal road and footpath. Within this buffer zones similar change analysis was performed using *Zonal Statistics* in ArcGIS and was compared within the road types as well as with the overall area. A motivation of this research work was to observe the impact of road network on forest land from a reasonable visible range. So, 0.75 km buffer was used, because, this is the range of observable distance, where observer can identify individual trees, building types, river pattern etc., according to a study of Bishop and Hulls (1994). A *view shade* analysis was also performed to consider the obstacles of hills from observation points. But it was found only minor area (below 5%) is not visible for such obstacle. However, the available Digital Elevation Model (DEM) data required for view shade analysis was only in 300m resolution which is not suitable for 30m resolution land class analysis. So, that approach was not applied later in this study. The results of the data analysis can be observed in Table 1.

Table 1: Changes in forest coverage in 20 years

Area coverage	Forest area in 1989 (sq. km)	Forest area in 2009 (sq. km)	Changes (%)
Total Area	34.03	20.88	39
Area within 0.75 km buffer of all roads	9.16	6.55	29
Area within 0.75 km buffer of metal road	2.86	2.87	0
Area within 0.75 km buffer of footpath	6.30	3.68	42

Table 1 shows that total forest area was 34.03 sq. km. in 1989, which declined to 20.88 sq. km in 2009 at a change of 39%. The change of forest areas within 0.75 km of any road is 29%, which is substantially lower than that of total area. Very minor or no change of forest coverage was detected within the 0.75 km buffer area of metal road, while, a massive change occurred in case of footpath at a rate of 42%. So, finally the result infer that deforestation or loss of forest coverage primarily occurs at near to the footpath as well as at in the remote sites. Whereas, the metal road; which are generally used for vehicular movement, spacious and conducive for other physical and infrastructural development; had low impact on forest coverage. With this conflicting result some interviews were conducted with local people and local staffs of Forest Department. According to their given information, following key features were identified: i) Forest Department is more active in forest conservation, improvement, and monitoring activities besides the metal roads, ii) at the same time, such management activities are much weak in the remote sites where little or no access to outsider people, iii) illicit hill cutting and wood cutting activities primarily occur through the footpath and then other remote sites, iv) encroachment of settlements is taking place in a continuous process along the footpaths, v) locally vested interested groups destroy the forest lands in the remote sites in absence of security personnel.

So, finally, based on the quantitative results gotten from remote sensing analysis and qualitative information given by the local stakeholders, it could be synthesized that infrastructure development is not always a considerable factor for forest land degradation and improved forest management could protect forest land in any places, wither it is in easily accessible areas or in remote sites.

Conclusion

Within the scope of this research work, various technical and non-technical issues of forest management could not be touched, but, the research findings would deliver an important message to the related stakeholders, that is, forest management should be ensured in a pragmatic way rather than just making visual impression.

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