# VEGETATION CHANGE DETECTION OF KHAGRACHHARI SADAR UPAZILA USING GIS AND REMOTE SENSING

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## Abstract

The change of vegetation in Khagrachhari Sadar Upazila during 1991 to 2021 was investigated taking data in 10 years intervals. Satellite images of Landsat 4-5 TM (30 October 1991, 19 March 2001 and 11 February 2011) and Landsat 8 OLI/TIRS (6 February 2021) from USGS Earth Explorer have been extracted. Image classification, analyzing and visualizing the data was accomplished by ArcGIS 10.7.1 software and Microsoft excel. In 1991, vegetation coverage (Forest and agriculture) and non-vegetated area (water body, bare land) were 161.15 $km^2$ (61.19%) and 99.17 $km^2$ (38.09%), respectively. After 10 years (in 2001) vegetation coverage slightly increased (by 0.83%) resulting a little decrease in non-vegetated area. The area became 184.63 $km^2$ (62.60%) and 97.28 $km^2$ (37.40%), respectively for vegetated and non-vegetated coverage. However, since 2011 a decreasing trend for vegetation coverage was observed, 161.81 $km^2$ (62.2%) in 2011 which decreased to 157.97 $km^2$ (60.72%) in 2021. Consequently non-vegetated area increased from 98.34 $km^2$ (37.80%) to 102.18 $km^2$ (39.28%) in this period. The overall loss of 3.18 $km^2$ of vegetation over the last 30 years was mainly due to rapid growth of population and encroachment of hilly area for settlement. This loss of vegetation coverage is affecting the ecological balance of the hilly areas of Bangladesh.

***Key words*:** Vegetation cover; GIS and Remote Sensing; Vegetation Change; Satellite.

## INTRODUCTION

Vegetation change detection as defined by Hoffer (1978) is temporal effects as variation in spectral response involves situations where the spectral characteristics of the vegetation or other cover type in a given location change over time. Vegetation is a general term for the plant life of a region; it refers to the ground cover provided by plants, and is, by far, the most abundant biotic element of the biosphere (BBS 2013).

Vegetation may include both man-made vegetation and natural vegetation. Man-made vegetation refers to as cultural vegetation or that which is planted by man or created or seeded by human intervention and it is seen where the main land is used for production e.g. wood and fiber, protection e.g. soil, water and other environmental values and conservation of biological diversity (Etim 2017). Natural vegetation is formed naturally without human intervention or without agricultural practices. The natural forests are physio-graphically divided into hill forest; inter-tidal mangrove forests (tropical evergreen) and plain land Sal-forest. They constitute 67%, 27% and 6% of the natural forest area and occupy 66%, 31% and 3% of the growing stock of 42.64 million, respectively (Khan *et al.* 2004).

Vegetation is psychologically important to humans, who evolved in direct contact with, and dependence on, vegetation, for food, shelter, and medicine. Vegetation is also an important part of the global carbon cycle because trees and plants absorb carbon dioxide through photosynthesis (Bashar 2007). By removing the greenhouse gas from the air, vegetation functions as terrestrial sinks meaning they store large amounts of carbon.

Vegetation serves several critical functions in the biosphere, at all possible spatial scales. Vegetation regulates the flow of numerous biogeochemical cycles, most critically those of water, carbon, and nitrogen; it is also of great importance in local and global energy balances. Such cycles

are important not only for global patterns of vegetation but also for those of climate. Vegetation of an area affects soil characteristics like structure, organic matter content, *etc.*, which are vital for sustainable productivity of a soil.

Vegetation serves as wildlife habitat and the energy source for the vast array of animal species on the planet. Vegetation is also critically important to the world economy, particularly in the use of fossil fuels as an energy source, but also in the global production of food, wood, fuel and other materials. Perhaps most importantly, global vegetation (including algal communities) has been the primary source of oxygen in the atmosphere, enabling the aerobic metabolism systems to evolve and persist.

This study is undertaken to identify the vegetation change in Khagrachhari Sadar Upazila through satellite images from the years of 1991, 2001, 2011 and 2021 and to create land use pattern map to monitor the changes of vegetation of the study area.

## MATERIAL AND METHODS

*Study area*

The area of Khagrachhari Sadar Upazila under Khagrachhari district is 297.92 km$^2$, located in between 23°00' and 23°21' north latitudes and 91°55' and 92°00' east longitudes. It is bounded by Panchhari upazila on the north, Mahalchhari upazila on the south, Dighinala and Langadu upazilas on the east, Matiranga upazila on the west. Khagrachhari Thana was formed in 1968 and it was turned into an upazila in 1984. Khagrachhari district is a hilly area. It is bounded by the Tripura state of India on the north, Rangamati and Chattogram districts on the south, Rangamati district on the east, Chattogram district and Tripura state of India on the west. Notable hill ranges are Golamoon, Chotto Panchari, Karmi Mura, Lutiban, Kuradia, Bhanga Mura, Jopisil. It has three rivers, namely Chengi, Feni and Maini. The Chengi river is the longest river in Khagrachhari. The maps of Khagrachhari district and Khagrachhari Sadar Upazila are presented in Fig. 1.

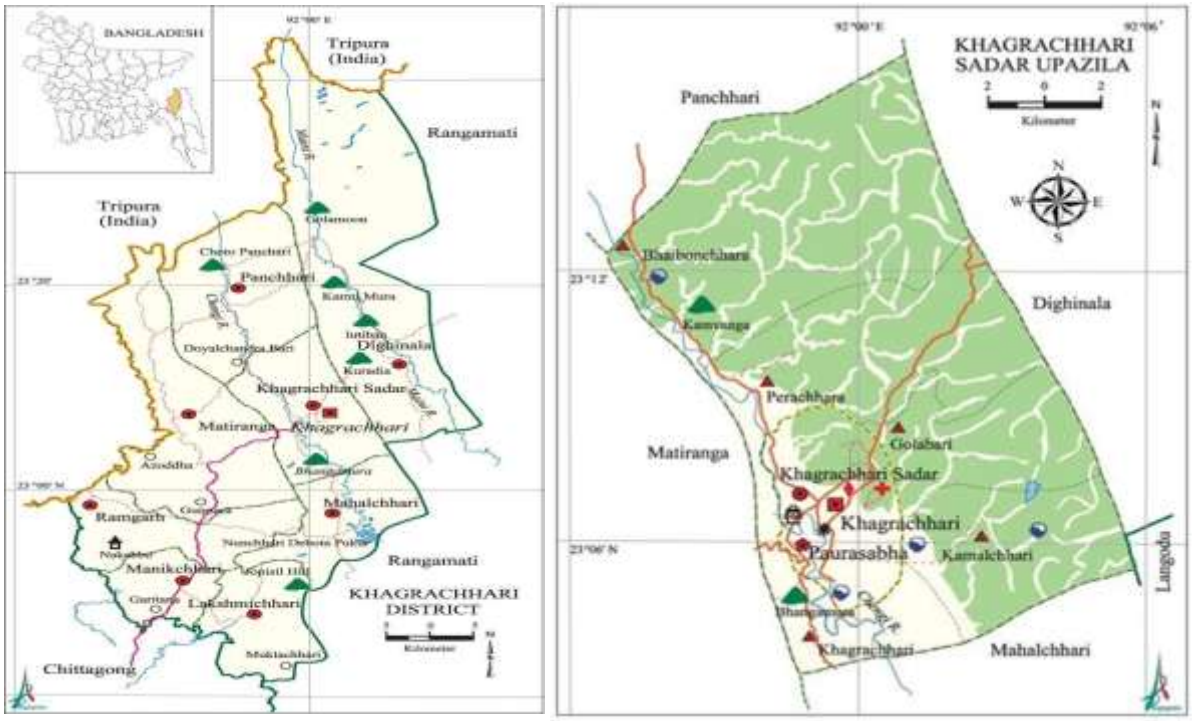


Fig. 1. Map of Khagrachhari Sadar Upazila (Source: Banglapedia 2021).

The main ethnic groups living in the district are Tripuris, Chakmas, Bengalis and Marmas. According to Bangladesh Population Census 2011, total Population is 6,13,917, with an annual growth rate of 1.54%; male 3,13,793, female 300,124, Muslim 3,82,849, Hindu 89,102, Buddhist 1,39,603, Christian 2157, and others 207. As per the 2011 Census, there were a total of 316,987 indigenous people in the district (51.63%).

*Data acquisition and methods*

To analyze the loss of vegetation coverage multi spectral and multi temporal Landsat satellite data of Khagrachhari Sadar Upazila for four years (1991, 2001, 2011 and 2021) were acquired. Satellite images of 1991, 2001 and 2011 were taken from Landsat 4-5 TM C2 Level 2 and the satellite image of 2021 was taken from Landsat 8 OLI/TIRS C2 Level-2. Spatial resolution of all these images were 30 meters and downloaded from USGS Earth Explorer. The detail of the images is provided in Table 1. A combination of unsupervised and supervised image classification is used to extract data on vegetation change and to make maps through ArcGIS 10.7.1. For analyzing data Microsoft Excel was used. The methodology was followed according to the technique adopted by Adia and Rabiu (2009).

**Table 1. Data characteristics and sources.**

| Satellite | Bands | Spatial Resolution | Date |
|---|---|---|---|
| Landsat 4-5 TM C2 Level-2 | 1,2,3,4,5,6,7 | 30x30 m | 30-Oct-1991 |
| Landsat 4-5 TM C2 Level-2 | 1,2,3,4,5,6,7 | 30x30 m | 19-Mar-2001 |
| Landsat 4-5 TM C2 Level-2 | 1,2,3,4,5,6,7 | 30x30 m | 11-Feb-2011 |
| Landsat 8 OLI/TIRS C2 Level-2 | 2,3,4,5,6,7,8,9,10,11 | 30x30 m | 06-Feb-2021 |

## RESULTS AND DISCUSSION

Most part of Khagrachhari Sadar Upazila (KSU) is covered by tropical semi-evergreen forest, generally evergreen in character but deciduous plants also dominate. However, in last few decades, increasing of the population and expansion of road networks, tourist spot, markets and settlement, most of nature (old growth) forests of the region have been lost and has brought under short-rotation shifting cultivation, crop-agriculture and plantations (rubber, teak, fruit trees). Thus, the biodiversity of the region, both flora and fauna, have depleted badly. Near to similar statement was found to present briefly by Islam and Sarker (2016) when they studied the subject under the research programme "Monitoring the Changing Pattern of Land Use in the Rangpur City Corporation Using Remote Sensing and GIS".

**Table 2. Land use pattern of Khagrachhari Sadar Upazila (1991-2021).**

| Land Use Category | 1991 | | 2001 | | 2011 | | 2021 | |
|---|---|---|---|---|---|---|---|---|
| | **Area** | | **Area** | | **Area** | | **Area** | |
| | **$km^2$** | **%** | **$km^2$** | **%** | **$km^2$** | **%** | **$km^2$** | **%** |
| Bare land | 92.57 | 35.55 | 89.67 | 34.47 | 71.60 | 27.52 | 81.48 | 31.32 |
| Forest | 136.97 | 52.62 | 118.63 | 45.60 | 134.13 | 51.56 | 134.92 | 51.86 |
| Agriculture | 24.18 | 9.29 | 44.22 | 17.00 | 27.68 | 10.64 | 23.05 | 8.86 |
| Water body | 6.60 | 2.54 | 7.61 | 2.93 | 26.74 | 10.28 | 20.70 | 7.96 |

Over 300,000 species of flowering plants under 95 families have been recorded in Khagrachhari forests. In the valleys and slopes Chapalish, Telsur, Chundul and Narkeli constitute the top canopy; Gutgutya, Toon, Pitraj, Nageswar, Uriam, Nalizam, Godajam, Pitjam, Dhakijam from the middle

storey; and Dephal and Kechuan constitute the lower storey. On the hotter and dryer slopes and on ridges different species of Garjan, Banshimul, Shimul, Shilkoroi, Chundul, Guja Batna, Kamdeb, Bura gamari, Bahera and Moose form the upper storey; Gab, Udal and Shibhadi from the middle storey and Adalia, Barmala, Goda, Ashoka, Jalpai and Darrum constitute the lower storey. The common deciduous species are Garjan, Simul, Bansimul, Batna, Chapalish, Toon, Koroi and Jalpai. The flora of these forests resembles those of eastern Himalayas in the north (Banglapedia 2021).

The derived satellite images are classified into 4 different categories such as bare land, forest, agriculture and water body to extract the data on total vegetated (forest and agriculture) area and non-vegetation coverage shown in Table 2. Fig. 2 is constituted for the visualization of land use changes over last 30 years (1999-2021).

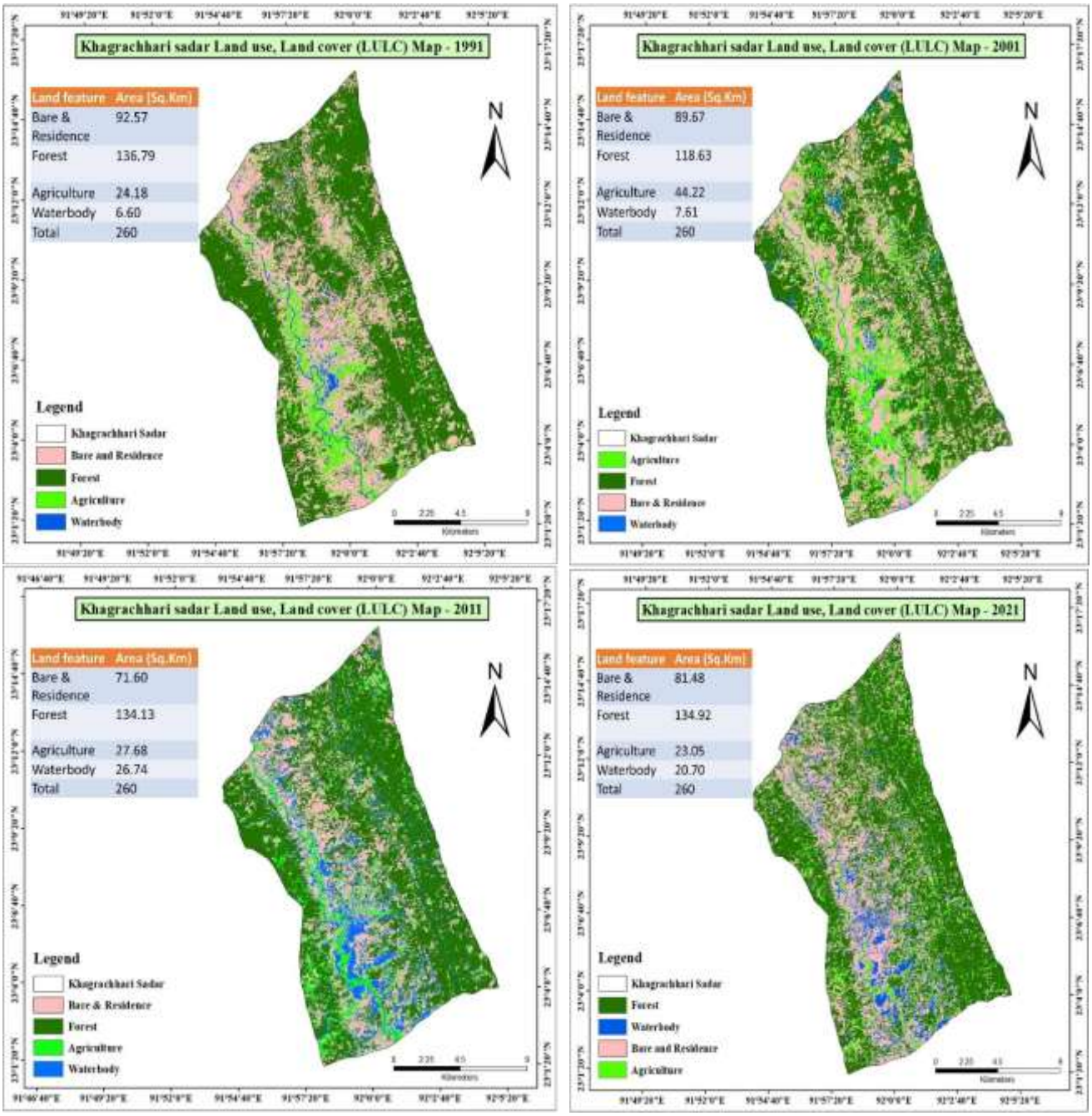

Fig. 2. Land use pattern of Khagrachhari Sadar Upazila from 1991-2021.

The fig. 3 shows that, in 1991 the vegetation coverage (Forest and agriculture) was 161.15 km$^2$ and 99.17 km$^2$ area was non-vegetation (water body and bare land). The vegetation coverage area of 2001 was found 162.85 km$^2$ and 97.28 km$^2$ area was non-vegetated. Therefore, the vegetation coverage increased by 0.83% from year 1991 to 2001. However, in 2011 vegetation coverage of the areas was 161.81 km$^2$ and 98.34 km$^2$ area was non-vegetated, which means vegetation coverage decreased by 0.42% from 2001 to 2011. Eventually, the vegetation coverage again decreased by 2.37% from 2011 to 2021; having the vegetated area of 157.97 km$^2$ and non-vegetated area of 102.18 km$^2$. It can be depicted from trend lines (Fig. 3) that the vegetation coverage for KSU has a decreasing trend where as non-vegetation coverage has increasing trend.

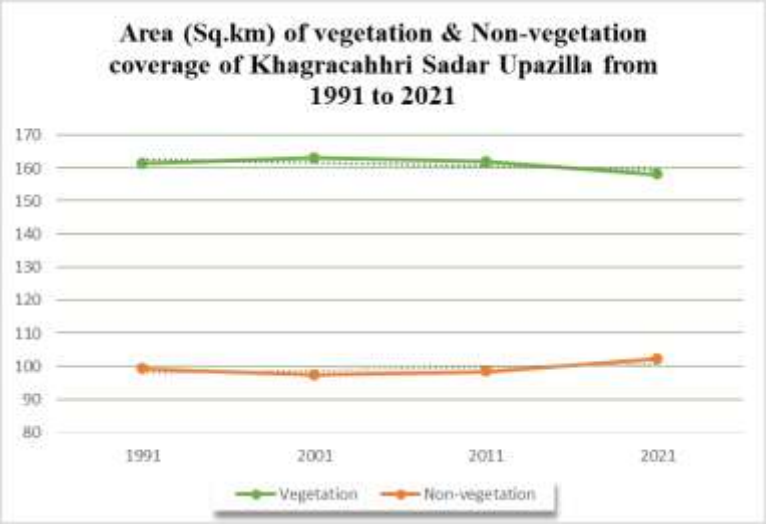


Fig. 3. Vegetation and non-vegetation coverage of KSU from 1991-2021.

The vegetation change from the years of 1991 to 2001 was +1.70 km$^2$ whereas from 2001 to 2011 it was -1.04 km$^2$ which became -3.84 km$^2$ from 2011 to 2021. Therefore, the overall change in vegetated area from 1991 to 2021 is -3.18 km$^2$ which means that the vegetation coverage has been decreased by 1.97% during last 30 years (Table 3). Mro (2021) reported the vegetation change was increased 1.73 km$^2$ in years 1998 to 2018 in Bandarban Sadar Upazila.

**Table 3. Change of vegetation coverage from 1991 to 2021.**

| Year | Change of vegetation coverage | |
|---|---|---|
| | Area (km$^2$) | Percentage (%) |
| 1991-2001 | +1.35 | +0.83 |
| 2001-2011 | -0.69 | -0.42 |
| 2011-2021 | -3.84 | -2.37 |
| 1991-2021 | -3.18 | -1.97 |

Roy *et.al* (2015) reported the dynamics of land use/ land cover changes and their future scenario in the tertiary southeastern hill tracts of Bangladesh. According to them the river and inland water bodies increased in the time span from 1989 to 2000. However, the areas decreased in 2014 by 0.11 % of the total area. There was a slight increase in the inland water reservoir from 1989 to 2000, but a substantial decrease was observed during 2000 to 2014.

This study was undertaken to find the vegetation change of Khagrachhari Sadar Upazila over last 30 years (1991-2021) by using GIS and Remote Sensing Techniques. The overall loss of vegetation in 1991 to 2021 was 3.18 $km^2$ which is 1.97% of the total vegetated area and 1.22% of total area of 1991. However, vegetation cover slightly increased from 1991 to 2001 but a decreasing trend in vegetation coverage observed from 2001 to 2021 whereas the non-vegetated area has increasing trend. Therefore, forests need to be saved by decreasing activities.

## REFERENCES

Adia, S. O. and A. B. Rabiu. 2009. Change detection of vegetation cover, using Multi-temporal remote sensing data and GIS Techniques. Geospatial World. Proceedings of Map India, 6-8 February 2008.

Banglapedia. 2021. https://en.banglapedia.org/index.php/Khagrachhari_District.

Bashar, M. A. 2007. Urban Forestry: Imperative for life in city. The Daily Star. 13 April.

BBS (Bangladesh Bureau of Statistics). 2013. *Economic census district report Khagrachhari*. Bangladesh bureau of statistics and informatics division ministry of planning government of the people's republic of Bangladesh. 2016. 447 pp.

Etim, J. 2017. *Vegetation-Definition, Types and Importance/Uses of Vegetation to Man*. Jot Scroll. 2nd Aug, 2017.

Hoffer, R. M. and M. D. Fleming. 1978. Mapping vegetative cover by computer-aided analysis of satellite data. Integrated inventories of renewable natural resources. Proceedings of the Workshop, Pulb. US Dept. Agri., pp. 227-237.

Islam, W. and S. C. Sarker. 2016. Monitoring the changing pattern of land use in the Rangpur city corporation using remote sensing and GIS. *J. Geograp. Inform. Sys.* **8**(4): 537-545

Khan, N. A., J. K. Choudhury and K. S. Huda. 2004. *Forestry Sector Review Report*. Bangladesh Forest Department, Ministry of Environment and Forest, Dhaka, Bangladesh.

Mro, M. 2021. *Vegetation Change Detection of Bnadarban Sadar Upozila Using GIS and Remote Sensing*. B. Sc. Thesis. Department of Environmental Science, Stamford University Bangladesh. 27 pp.

Roy, S., K. Farzana, M. Papia and M. Hasan. 2015. Monitoring and prediction of land use/land cover change using the integration of markov mhain model and cellular automation in the southeastern sertiary silly sreas of Bangladesh. *Int. J. Sci. Basic Appl. Res*. **24**(4): 125-148.