

Assessing Biogeomorphological State of the Teesta River Flood Plain: A Study on Gangachara Upazila, Rangpur, Bangladesh

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How to cite this paper: Islam, S. and Sarker, S.C. (2017) Assessing Biogeomorphological State of the Teesta River Flood Plain: A Study on Gangachara Upazila, Rangpur, Bangladesh. *International Journal of Geosciences*, 8, 265-275.

<https://doi.org/10.4236/ijg.2017.82011>

Received: January 9, 2017

Accepted: February 25, 2017

Published: February 28, 2017

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Abstract

Teesta river flood plain is one of the most significant landscapes in Bangladesh. The main theme of this research was to assess the present biogeomorphological state (biomass, herbaceous vegetation species, density of all vegetation species, flood plain extension mapping) of Teesta river flood plain under Gangachara upazila. The research work was conducted based on the objectives to prepare a map of Teesta river flood plain extension area, to estimate herbaceous vegetation (biomass, species types), and to find out the vegetation density to assess the present biogeomorphological state of study area. To present the flood plain area of Teesta river in the Gangachara upazila, base map has been used; herbaceous vegetation samples have been collected through quadrat method to estimate biomass (both in dry and before dry condition) using digital weight machine; vegetation density has been shown through NDVI of satellite image (Landsat-8) using red and NIR band in ArcGIS 10.1 software. From the results of this research, river flood plain area is found 68.5 sq. km; total 31 types of herbaceous species have been identified where *Pouzolzia indica* is the most dominated species covering 11.59% of the total area; maximum DN value of NDVI is found +0.475242 which represents the highest vegetation density covering an area of 78 sq. km of the total area. The research may assist for the further study of river flood plain biogeomorphology throughout the country as well as in the world.

Keywords

River Flood Plain, Biomass, NDVI, Herbaceous Vegetation, Quadrat

1. Introduction

River flood plains are among the most fertile and richest ecosystems on the

earth, thus, it has been very essential to manage properly. Biogeomorphological state of any river flood plain indicates the usefulness of it. Study of herbaceous vegetation (biomass, species types) through quadrat method, NDVI, is significantly helpful to bring out the present real scenario of biogeomorphological state of a river flood plain area. River flood plains are important landscapes features for retaining river nutrients and sediment loads [1]. The river flood plain is typically defined as narrow strip on each side of the river channel [2]. Thus, flood plain lies between natural levee and flood basin and is lower in elevation than that of natural levee [3]. This is primarily due to periodical floodplain inundation [4], thus is seasonal recruitment habitat [5] which replenishes the soil nutrients and sustains a high level of landscape diversity. River flood plains are environments that alternate between wet and dry phases, with lower lying parts being wet than dry and higher parts being more dry than wet [6]. Flood plains are habitat for terrestrial biota during dry phase, and in wet phase, flood plains are habitat for aquatic fauna and mobile species such as fishes, grasses, etc. [7]. Historically, humans have used rivers flood plain more than any other types of ecosystem [8]. The term biogeomorphology was first used in the eighties [9]; biogeomorphology is a relatively new discipline within the study of river flood plain system. Biogeomorphological (flora and fauna based on the development of land formation) state of any landscape helps us to understand the fertility, productivity as well as the total ecological scenario of the specific region [10]. Herbaceous vegetation species' (density, biomass) study based on satellite imageries provides an idea of river flood plain ecology [11]. Biomass measurement of vegetation (herb, shrub and tree) using quadrat method is an important ecological property to understand the river flood plain landscape pattern [12]. Vegetation types related to basin geomorphology will provide a basis for future restoration planning regarding river flood plain [13].

The Teesta river flood plain presents a very typical biological and geomorphological characteristic and behavior. This river channel represents a normal flow of the moribund and mature hydrological situations of a flood plain environment. Although the Teesta presently carries a very poor discharge of water, still it is the major river of the northern part of Bangladesh influencing greatly in the agricultural sector and as a major tributary of Jamuna River [14]. The Teesta river flood plain plays a vital role in the overall ecological and socio-economic life of Gangachara upazila. At least 75,000 [15] thousands of people Gangachara upazila are somehow dependent on the Teesta and its biogeomorphological settings. It is a time of concerning to study about river flood plain for ensuring the current human demand due to rapid growth of population and industrialization. River flood plain of Gangachara upazila developed by Teesta river flowing from the northern part of Bangladesh toward southern part as major tributary of Jamuna river is biogeomorphologically as well as geopolitically significant to study. That is why assessment of herbaceous vegetation biomass using quadrat method and NDVI using Landsat satellite image were adopted to find out the present biogeomorphological state of Teesta river flood plain area.

2. Study Area

River flood plain is one of the most significant landscapes that historically roles in livelihood of human being including socio economic as well as cultural aspects through its diverse and effective ecological settings that is why it is considered as biological super market. At present, river flood plain is more concerning issue throughout the world. In this research the study area biogeomorphologically is facing vulnerable situation day by day as it is losing adequate amount of water discharge from upper stream due to geopolitical issues between Bangladesh and India. It is time to think about the problem to manage the flood plain area. Teesta river flood plain is the most significant landscape in the north-western part of Bangladesh that falls in the old Himalayan piedmont plain comprising of recent flood plain deposits [16]. The Teesta river flood plain in the Gangachara upazila presents a very typical biological and geomorphological characteristics or behavior. The present study area map provided from BWDB is located in the Gangachara upazila under the Rangpur district of northern part of Bangladesh. **Figure 1** shows that Gangachara upazila is located between 25°48' and 25°57' north latitudes and between 89°05' and 89°21' east longitudes covering an area 272.28 sq. km where total land area of 206.45 sq. km, is bounded by Kaliganj (Lalmonirhat) and Jaldhaka (Nilphamari) upazilas on the north, Rangpur Sadar and Kaunia upazilas on the south, Aditmari and Lalmonirhat sadar upazilas on the east, Kishoreganj (Nilphamari) and Taraganj upazila on the west.

3. Materials and Methods

3.1. Materials

The research work has been conducted based on the both primary and secondary data sources; primary data has been collected through field survey regarding herbaceous vegetation from the study area. Secondary data were collected through

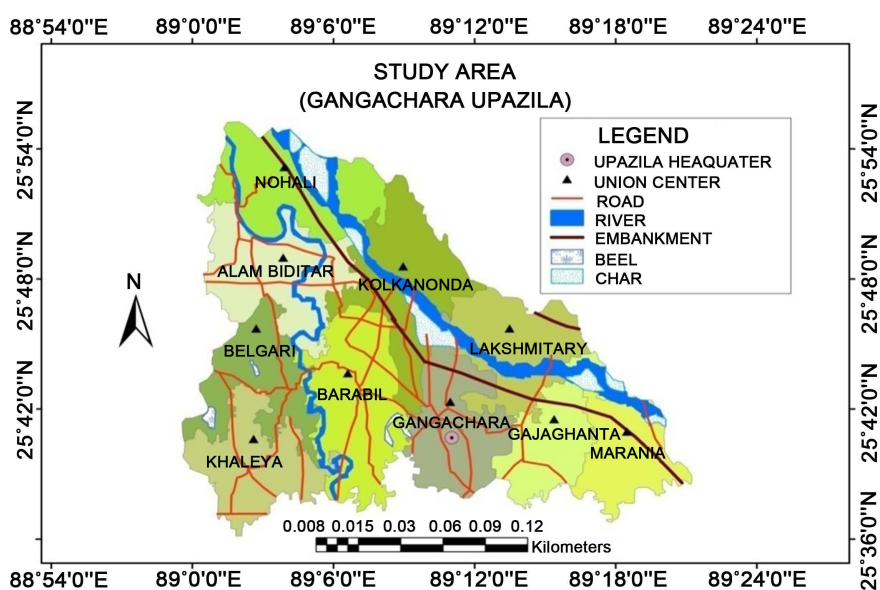


Figure 1. Map of the study area (Gangachara upazila).

base map provided from BWDB, satellite image (Landsat-8) was collected from SPARSSO, and data has been processed using MS Excel, ArcGIS 10.1, and ArcGIS 9.3 software.

3.2. Methods

The research work has been conducted based on considering about the biogeomorphological state of Teesta river flood plain in Gangachara upazila, there has been selected the study about mapping of flood plain area, herbaceous vegetation (biomass, species type), vegetation density, and where map of Teesta river flood plain extension area has been made using ArcGIS 9.3 software based on the study of base map provided by BWDB. For the measuring biomass of herbaceous vegetation total 104 sampling area has been selected through quadrat method using 1 square feet bamboo frame after the distance of every 200 meter that covered total area 104 sq. feet in river flood plain area, after collecting herbaceous species from the river flood plain area biomass has been measured both in dry (40°C oven drying) and before dry condition using digital weight machine, in the study of herbaceous vegetation, there have found 31 species in the river flood plain area that have been identified after the procedure of ICBN (International Code of Botanical Nomenclature). Satellite image of vegetation condition of 2015 was acquired on March 8 (with a map projection of WGS_ 84) has been used for the NDVI mapping to know present state of vegetation scenario of the study area. The image was stacked in the ArcGIS 10.1 software for image classification to make NDVI. Those three processes mostly help in assessing about the biogeomorphological state of river flood plain area as well as Teesta river flood plain in Gangachara upazila.

4. Result and Discussion

4.1. Mapping of Teesta River Flood Plain Extension Area in Gangachara Upazila

The study area showed in **Figure 2** about the delineation of Teesta river flood plain area and other types of landformation in the Gangachara upazila.

Table 1 showed that total area of Gangachara upazila is 272.28 sq. km from where Teesta river flood plain area was found out 68.5 sq. km covered by 25.15% of the total area based on the measuring regularly inundated area by Teesta river in which average length in both bank side was 27.4 km and average wide of flood plain from bank up to 500 meter (0.5 km) toward landmass in southern part where as average width in the northern part was found 2 km.

Figure 3 represented total river flood plain area covering 25.15% of the total, and 74.85 % was covered by the other types of land formation in the study area.

4.2. Records of Herbaceous Vegetation of Teesta River Flood Plain in the Gangachara Upazila

The biomass pattern of study area has been estimated in square feet for every sample. Through the quadrat method sampling was taken. The depiction in the

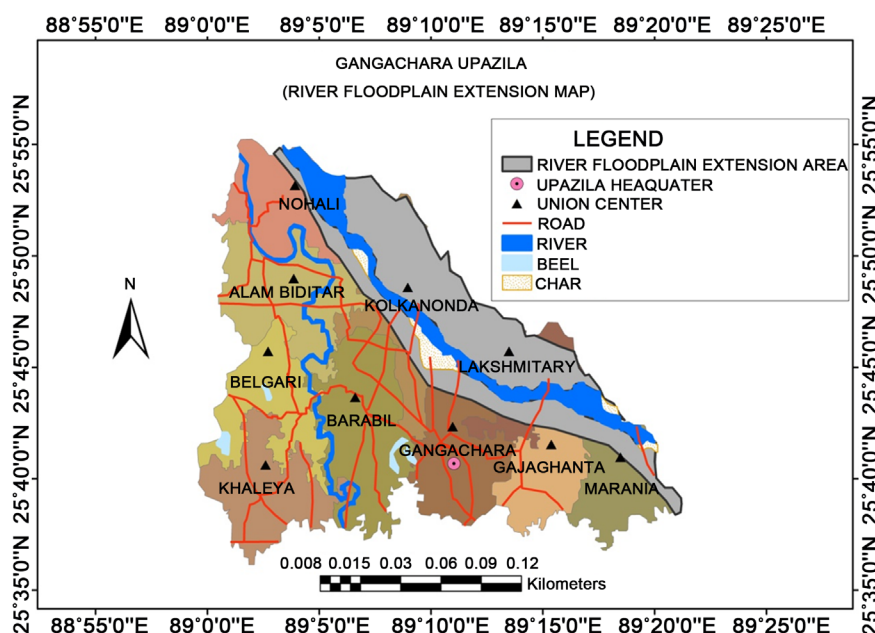


Figure 2. Teesta river flood plain extension area in the Gangachara upazila.

Amount of Teesta river flood plain area and other types in Gangachara upazila

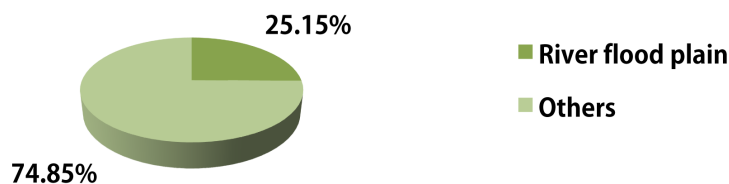


Figure 3. Amount of Teesta river flood plain area and other types in the Gangachara upazila.

Table 1. Amount of Teesta river flood plain area and other types in the Gangachara upazila.

Total area (sq. km)	Category	Area	Percentage (%)
272.28	River flood plain	68.5	25.15%
	Others	203.78	74.85%

Table 2 narrates that the total sampling area was 104 square feet. Total biomass in green condition (before dry) was 7.719 kg/104 sq. feet; total biomass after dry of vegetation was 3.191 kg/104 sq. feet, and the difference between two biomass pattern (before dry and after dry of vegetation) is 4.528 kg/104 sq. feet. Total number of species population was 11,343, where species type total was 31.

4.2.1. Biomass Pattern of Herbaceous Vegetation of Teesta River Flood Plain in the Gangachara Upazila

Table 3 showed that the total sampling areas were 104 sq. feet, where total biomass of herbaceous vegetation 7.719 kg (before dry) that covered 70.75% of total area and 3.191 kg in (after dry) that covered 29.24% of total area.

Table 2. Records of herbaceous vegetation (biomass, number of species type) of Teesta River flood plain area in the Gangachara upazila.

Total surveyed area (sq. feet)	Total biomass (before dry)	Total biomass (after dry)	Difference between biomass (before and after dry)	Total number of population (density/sq. feet)	Total no. of identified species
104	7.719 kg	3.191 kg	4.528 kg	11343	31

Table 3. Total amount of herbaceous vegetation biomass (before dry and after dry) in the Teesta river flood plain area (Gangachara upazila).

Total area (sq. feet)	Biomass of herbaceous vegetation (Kg.)		Percentage (%)
104	Biomass (before dry)	7.719	70.75 %
	Biomass (after dry)	3.191	29.24 %

According to **Figure 4** biomass before dry condition of herbaceous vegetation was three times larger than biomass in after dry of vegetation; the difference was due to the result of drying vegetation in 40°C in oven as moisture, water content and others content in the vegetation is lost. So, net biomass is 4.528 kg.

In **Table 4**, there has been shown biomass of herbaceous vegetation of the Teesta river flood plain area as average, maximum and minimum both in dry and before condition for comparative analysis through field survey. These patterns of biomass have been found through the measuring of the total 104 quadrat samples separately in the study area. Each sample has been measured separately in where maximum value of a quadrat covered sample showed 0.210 gm/sq. feet in the before dry condition of herbaceous vegetation and that showed 0.088 gm/sq. feet in after dry condition. Like that a sample contained the value 0.001 gm/sq. feet represented minimum amount of biomass pattern which has been showed 0.00024 gm/sq. feet in after dry condition and average value of biomass were showed 0.07 gm/sq. feet and 0.03 gm/sq. feet comparatively in before dry and after dry condition of herbaceous vegetation. **Figure 5** showed the comparison of biomass pattern in the study area.

4.2.2. Density of Identified Herbaceous Species in the Flood Plain of Gangachara Upazila

Table 5 represented that there has been found 31 types of herbaceous vegetation species in the study area. The most dominated species type of the Teesta river flood plain area in the Gangachara upazila was *Pouzolzia indica* (moishma ghas) that covered at about 11.59% of total area and the lowest type of species was *Calocasia esculenta* (kachu), *Mimosa padica* (lajjabati) etc. that covered 0.31 % of total area.

4.3. NDVI and Vegetation Density Map of Gangachara Upazila

Figure 6 showed that, green color containing DN value 0.475242 represented highest vegetation covered area on the other hand red color containing DN value

Table 4. Maximum, minimum and average amount of biomass (before dry and after dry) in the Teesta river flood plain area of Gangachara upazila.

Biomass of vegetation	Category	Amount (gm/sq. feet)	Percentage (%)
Before dry	Average	0.07	24.91 %
	Maximum	0.210	74.73 %
	Minimum	0.001	0.36 %
After dry	Average	0.03	25.37 %
	Maximum	0.088	74.42 %
	Minimum	0.00024	0.21 %

Table 5. Density of identified herbaceous species in the Teesta river flood plain area of Gangachara upazila.

SL. NO.	Local Name	Scientific Name	Density (%)
01	Moishma ghas	<i>Pouzolzia indica</i>	11.59
02	Amrul	<i>Oxalis corniculata</i>	9.09
03	Moina ghas	<i>Cymbopogon citratus</i>	8.15
04	Chapra ghas	<i>Elusine indica</i>	6.89
05	Durba ghas	<i>Cynodon dactylon</i>	5.95
06	Kelna ghas	<i>Cyperus rotundus</i>	5.64
07	Nunia shak	<i>Portulaca oleracea</i>	5.64
08	Helencha	<i>Aristida leucas</i>	4.38
09	Fotka	<i>Physalis micrantha</i>	4.38
10	Bilaikhamchi	<i>Achyranthes aspera</i>	4.38
11	Bicha ghas	<i>Kyllinga nemoralis</i>	4.07
12	Kalmi	<i>Ipomoea aquatica</i>	3.44
13	Okhra	<i>Chrysopgon aciculatus</i>	3.44
14	Notay shak	<i>Amaranthus viridis</i>	3.13
15	Keshuti	<i>Eclipta alba</i>	2.50
16	Bhuishak	<i>Ludwigia hyssopifolia</i>	2.50
17	Kanta morich	<i>Amaranthus spinosus</i>	2.50
18	Muktajhuri	<i>Acalypha indica</i>	1.56
19	Jhunjhuni ghas	<i>Croton bonplandia</i>	1.56
20	Bish Dhekia	<i>Pteris pellucida</i>	1.56
21	Bishkatali	<i>Persicaria barbata</i>	1.56
22	Keshur	<i>Actinoscirpus grossus</i>	1.25
23	Lal Bishkatali	<i>Persicaria acuminata</i>	1.25
24	Kanshisa	<i>Leucas aspera</i>	0.62
25	Foksa	<i>Cyperus laxus</i>	0.62
26	Shada Dhekia	<i>Diplazium esculentum</i>	0.62
27	Kachu	<i>Calocasia esculenta</i>	0.31
28	Lajjabati	<i>Mimosa padica</i>	0.31
29	Shoti	<i>Curcuma zedoaria</i>	0.31
30	Pan pata	<i>Peperomia pellucida</i>	0.31
31	Bish Kachu	<i>Alocasia cucullata</i>	0.31

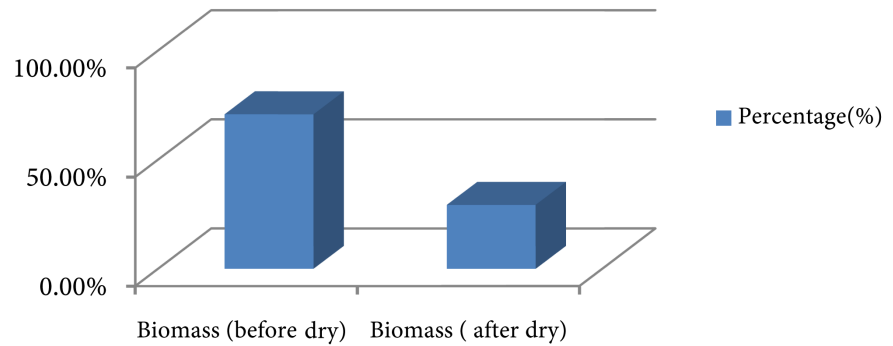


Figure 4. Biomass condition of herbaceous vegetation in the Teesta river flood plain area under Gangachara upazila.

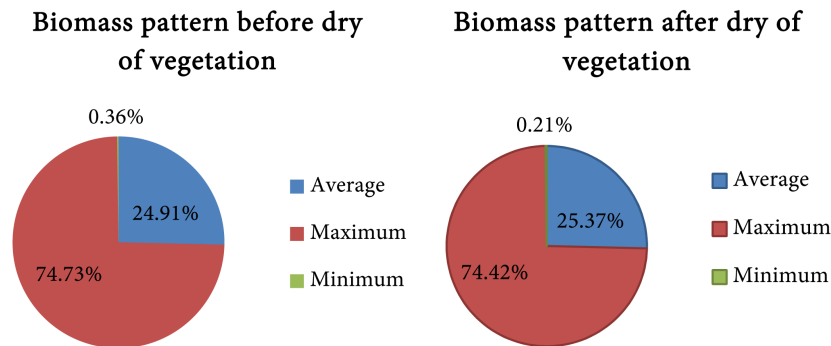


Figure 5. Comparison of biomass in different pattern both before dry and after dry of herbaceous vegetation.

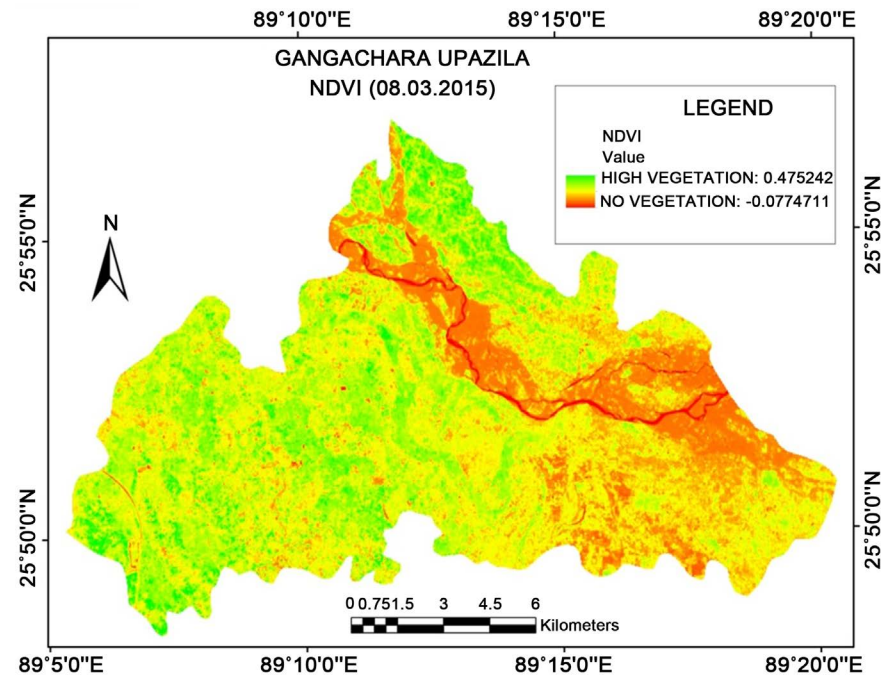


Figure 6. NDVI map of vegetation of Gangachara upazila.

-0.0774711 represented no presence of vegetation and **Figure 7** has been prepared for showing density pattern of vegetation of Gangachara upazila.

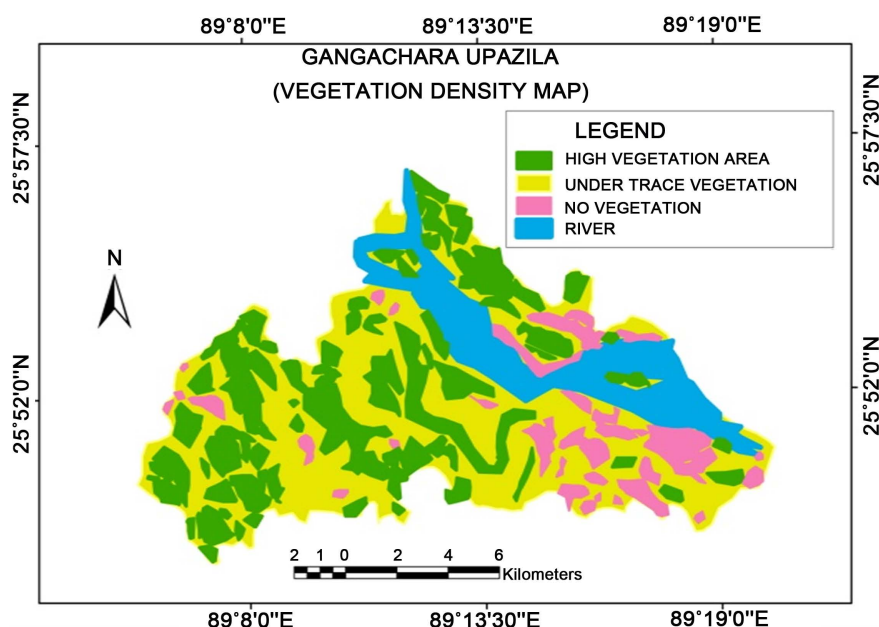


Figure 7. Density map of vegetation of Gangachara upazila.

Vegetation Covered Area of the Gangachara Upazila in 2015

Table 6 represented the different category of vegetation covered in the study area and **Figure 8** represented that high vegetation covered area in Gangachara upazila is 78 sq. km which covers 28.64% of total area, where as under trace vegetation was covered 61.08% and no vegetation was covered 10.28% in the Gangachara upazila.

5. Conclusion

The aim of the study was to assess the present biogeomorphological state of the Teesta river flood plain area. The present research work was based on the combine application of field survey, lands at satellite image processing, flood plain extension mapping, etc. Firstly, total river flood plain area has been estimated 68.5 sq. km, from that flood plain area, herbaceous vegetation samples have been collected to analyze biomass state where total sampling area is 104 sq. feet and total 31 types of herbaceous species are identified. NDVI operation has been run to find out the mostly vegetation covered area classified into dense vegetation and no vegetation covered area; the DN's value of NDVI is 0.475242 representing high vegetated areas and the DN's value -0.0774711 shows no vegetation covered area in the Gangachara upazila. However, based on the analyzing of herbaceous vegetation biomass, NDVI, the present biogeomorphological state of Teesta river flood plain area under Gangachara upazila was assessed, where especially the condition of herbaceous vegetation was assessed based on showing species types and biomass in dry and before dry condition. It has been found that, Teesta river flood plain changes its real nature due to many types of human interruptions and loses its biological status. So, it is a burning issue to study its current biological state. In accordance with that, the herbaceous vegetation study and NDVI operation have been adopted. This research will provide important guidelines

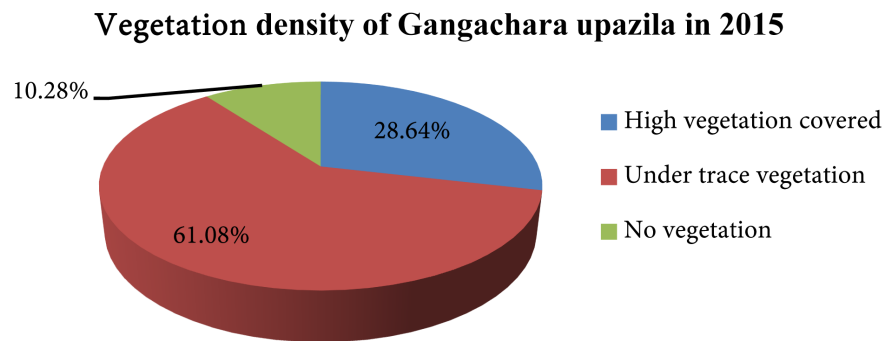


Figure 8. Pattern of vegetation density of Gangachara upazila in 2015.

Table 6. Vegetation density in the Gangachara upazila, 2015.

Total area (sq. km)	Category	Area (sq. km)	Percentage (%)
272.28	High vegetation covered	78	28.64%
	Under trace vegetation	166.28	61.08%
	No vegetation	28	10.28%

for better use of river flood plain area as well as will assist river planners, researchers, engineers, administrator, geographer, farmers, and local inhabitants in their respective fields fruitfully.

Acknowledgements

Authors would like to acknowledge SPARSSO, BWDB and chairman of the Department of Botany of Carmichael College for providing necessary data for the purpose of completing the research work.

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