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Research Article

Access of Land Degradation in A Plateau Region: A Case Study of Eastern Chotanagpur Plateau, India

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ABSTRACT

Land degradation processes are characteristically different in the tropical and temperate environment. The main purpose of this study is the physical process and the current level of land degradation in the coastal plateau. The Chotanagpur plateau is one of India's most damaged locations due to water erosion. The Shilabati River basin is a true representation of the tropical environment, Granite gneiss geology, Low to moderately developed soil Deteriorating lateritic upland landscape, high drainage density, low to moderately heavy rainfall (100–140 cm), dry tropical deciduous forest cover. The physical parameters used in the study of land degradation include physiographic formations, hydrologic properties, and vegetation cover. Water erosion, vegetation deterioration, and a loss in soil quality are the principal land degradation processes in the study area. The development of undulating landforms is due to the granite-gneiss geologic formation. High soil erosion is caused by underdeveloped soil profile, low organic matter content and poor soil structure. High terrain and sloping terrain create an unstable environment. Fragmented plateaus reduce productivity due to topographic constraints. Considerable the intensity and frequency of drainage in the house increases with the slight slope of the forest towards the large soil land, and erosion is strong. Decreased rainfall and increased dryness (less P/PET) increase water stress. Green biomass coverage also decreases. The difference between land degradation areas can be found by superimposing many important physical assets (geological formations, soil properties, land features, etc.) in the GIS environment. The backstory of the central Shilabati Basin is highly degraded and is particularly susceptible to land degradation.

Keywords: Land degradation, Shilabati River, tropical environment, laterite plateaus, rugged terrain, drought, GIS environment.

1. Introduction

Loss of land productivity, degradation of natural resources and biodiversity is defined as land degradation. The direct cause of soil degradation is soil erosion, deforestation, cutting of large number of plants, crop rotation, overgrazing, crop rotation, unbalanced fertilization, irrigation, soil loss, etc. Different types of soil degradation include loss of soil fertility, waterlogging, wind erosion, salinization, lowering of soil levels, deforestation, pasture degradation, forest degradation and soil pollution. Different processes of soil degradation - (i) Vegetal degradation; this types of degradation have observed in deforested, forest blank and shifting cultivation areas. Degradation in grazing, grassland and scrubland have also come under vegetal degradation. (ii) Water erosion; erosion by sheet, rill and gully have come under this categories. The humid and sub-humid subtropical areas are mostly affected by water erosion. (iii) Wind erosion; types of erosion pertains by aeolian activities. The cold and hot desert areas of all over the world are mostly affected by this processes of degradation. (iv) Salinization or alkalization; The areas of high evapotranspiration and vast irrigation are primarily affected by salinization and alkalization leads to land degradation processes. The irrigated areas of desert and desert fringe areas are primarily affected by this processes of degradation. (v) Waterlogging; The areas of undrained, low elevation profound and shallow water level areas are prone to water logging. The coastal low lying and foothill areas are most affected by this process. (vi) Mass wasting; This is the processes by which the downslope movement of rock, debris, regolith are pronounced. The mountainous areas, especially cold- dry areas are mostly affected by this processes of degradation. Landslide and scree slope is a specific example for this processes of degradation. (vii) Frost heaving; processes by which the intense frost and freezing of water evolve peculiar forms of rock, soil, and regolith in glacial and periglacial environment. (viii) Frost Shattering; Water freezes and thaws primarily in periglacial environments. This process is most active in periglacial environments. And adjoining areas of glacial margins. (ix) Man-made activities; such as mining, quarrying, brick kilns, industrial waste, urban agriculture, and city trash all contribute to land degradation. (ISRO 2007)

Granite gneiss geological formations, future land cover and undulating plateau topography are the main topographic features of the Eastern Chotanagpur Plateau. The main hydrological characteristics are high drainage density and growing aridity. The Shilabati basin, which possesses all of these qualities, has been selected for the current study. This study aimed to achieve two main objectives-

- The goal is to comprehend the many physical processes and variables contributing to land degradation on the eastern Chotanagpur plateau.
- To estimate the given basin's vulnerability to land degradation.

2. Study area

The river basin is an essential geomorphological unit for examining land degradation characteristics. The selected basin is located on the eastern side of the Chotanagpur Plateau. The basin is essentially part of the Ganges River system. Shilabati flows eastward from the Chotanagpur plateau through the undulating plateaus at the edge of the plateau. High slope, background layer, poor soil, undulating terrain, high rainfall and high-water level are the factors that led to the selection of Shilabati Basin as a representative hot area in the Chotanagpur Plateau. The basin's principal physical mechanisms of land degradation include geological impediment, soil degradation, undulating physiography, rill and gully-related water erosion, and vegetal-forest degradation.

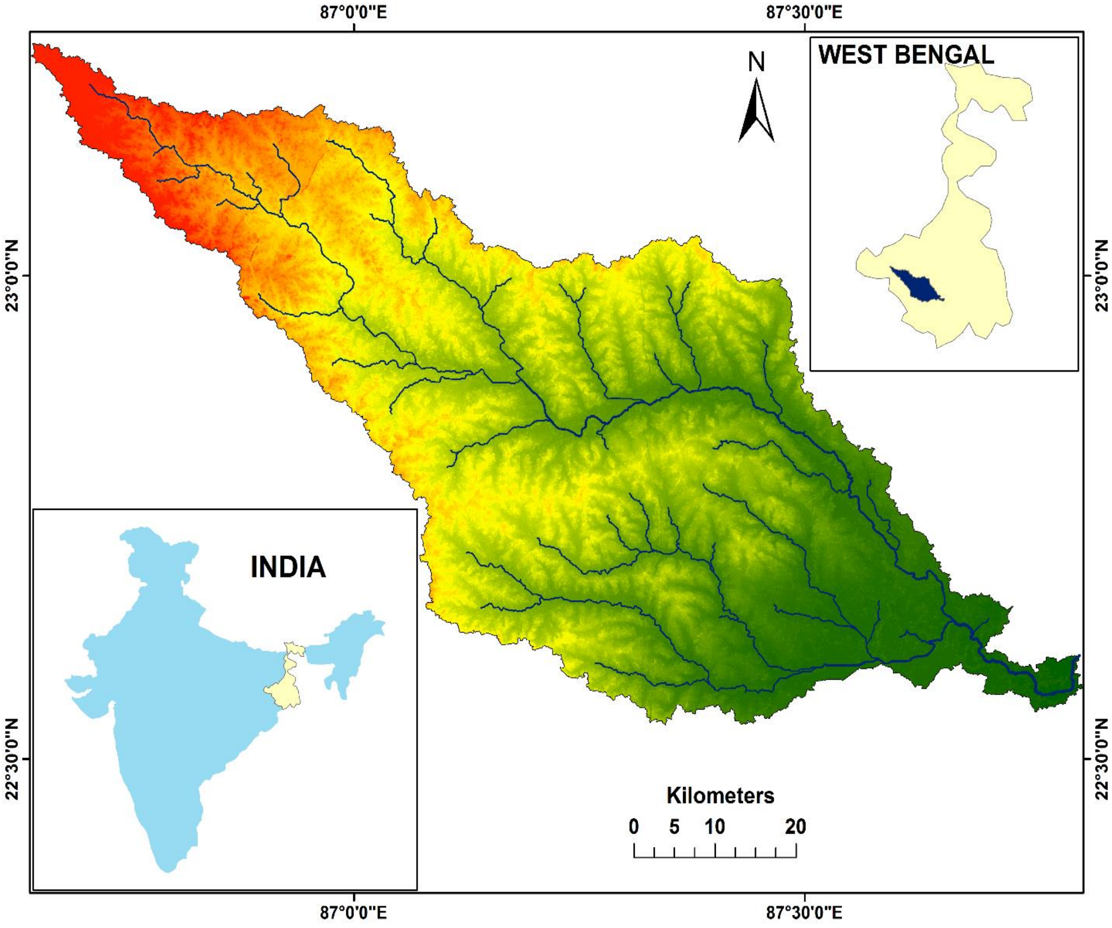


Figure 1: Shilabati River Basin Location Map

3. Materials required and methods

The process of land degradation is different in regions with different climate patterns. The African peninsula and the mountainous regions of Asia have low groundwater and poor soil quality. The plains of major rivers of all countries are degraded by floods and mixed salt water. Different indicators of soil degradation have been

investigated in tropical regions around the world. Riza et al. (2017) investigated various aspects of alluvial land degradation in the tropics. However, the study did not address the problem of soil degradation in tropical regions. Many studies assessing land degradation use only remote sensing (Hereher and Ismael 2016). However, studying soil degradation processes has significant limitations. Identification of lower land mass by spectral measurements has also been criticized (Kannan et al., 2017). 2015). Most studies cover soil processes associated with desertification in tropical environments (Allbed and Kumar 2013; Modaihsh et al. 2015). However, this is not the case in hot wet areas. Many studies focus on climate change and land degradation (Abdelrahman et al., 2017). 2015). However, land degradation on tropical plateaus is caused by a combination of land, water and climate. Therefore, examining specific processes does not provide insight into soil degradation. Remote sensing and geographic information systems (GIS) technologies are used worldwide to understand land degradation (Salih et al., 2015; González and Rodríguez, 2013).
Various geographical changes such as geological structure, soil properties, terrain properties, slope characteristics and terrain patterns in the basin are related to the degradation characteristics of the soil. Groundwater characteristics, surface water (drainage density/drainage frequency) characteristics, and precipitation-induced drought (P/PET) all contribute to soil degradation. All these measurements are measured independently for the entire basin. These parameters were studied using various remote sensing methods, secondary sources and data analysis (Table 1). All these factors are interrelated. Therefore, the process of soil degradation in each mountainous region can only be fully studied. Differently weighted rasters were created for different physical parameters of the river (ranging from 100 to 200; 200 = maximum disturbance, 100 = minimum disturbance). The weighting is given by taking into account the likelihood of soil degradation for the relevant amendments. The Arc GIS Raster Calculator function multiplies rasters by physical weight. Output screening identifies the flow of water by understanding the physical processes that cause soil degradation.

Physical vulnerability index of land degradation = (Geological formations * Soil properties * Topographic features * Slope formations * Topographic features * Ground soil (mbgl) fluctuations * Drainage density * Drought conditions (P/PET) * Green biomass cover) ˆ 1/9 .... (1)

Table 1 ***Data sources and techniques for different physical factors of land degradation study***

Physical factors	Data types & Year	Techniques
Geological formations	Map of 'Geological Survey of India' (GSI). 2011	GIS mapping for different geological characteristics.
Soil characteristics	Map of 'National Bureau of Soil Science'(NBSS). 2013	GIS mapping of soil characteristics.
Relief characteristics	ASTER DEM 30m. 'USGS Earth Explorer'. 2011	Elevation map for different reliefs.
Slope formations	ASTER DEM 30m. 'USGS Earth Explorer'. 2011	Slope mapping for different slope classes.
Geomorphological features	ASTER DEM 30m. 'USGS Earth explorer'. 2011	GIS mapping for geomorphological characteristics.
Groundwater fluctuation	MBGL data of 'Central ground water board' (CGWB). 2011	Groundwater depth maiing for different classes.
Drainage density	ASTER DEM 30m. 'USGS Earth Explorer'. 2011	Drainage density mapping (Drainage length/Sq.km).
Aridity conditions	Daily temp. & rainfall data of 'Indian Meteorological Dept.' (IMD). 1960-2015	Aridity (P/PET) mapping for different classes.
Green biomass cover	Landsat8 OLI image 'USGS Earth Explorer'. 2016	NDVI creation for different classes.

4. Results and Discussions

4.1. Physical process of land degradation in Shilabati River Basin.

The physical differences and process of land degradation in Shilabati River Basin are discussed below.

4.1.1 Geological Structure

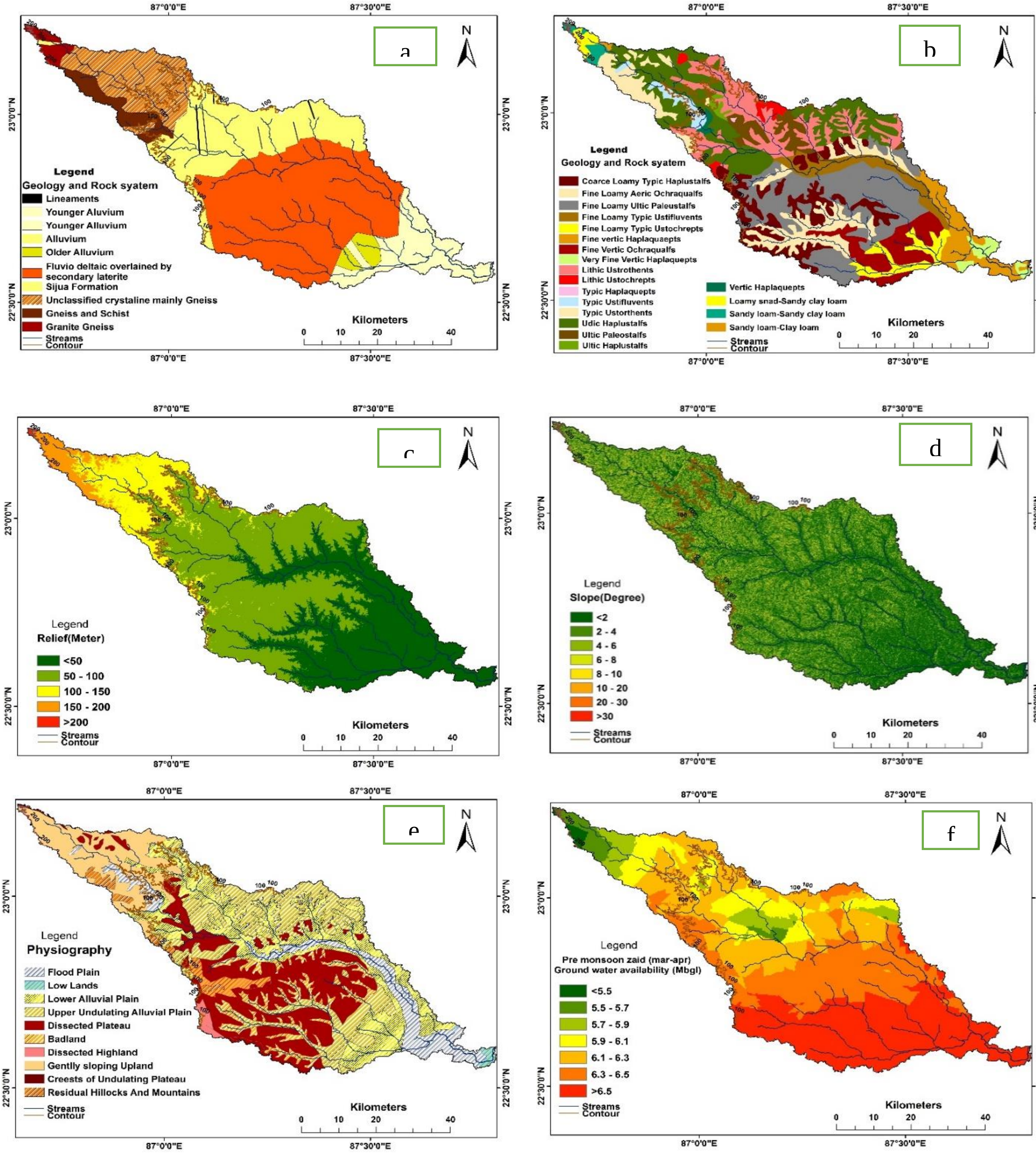
Geological structure and related minerals determine the fertility and production capacity of the soil. Geological formations also control surface areas such as topography, slope, and topographic features. Geological features affect soil depth, soil area and area. Archaean rock systems dominated by granite and gneisses are areas in the world where soils are not fully developed (Bocco et al., 2017). 2001).
The northern part of the Shilabati Basin is geologically covered with granite gneiss and schists (Fig. 2.a) (Dolui et al. 2014). The granite-gneiss-schist geological structure in the upper parts is not well differentiated and

hinders land development to a great extent. This situation leads to low soil development, undulating topography and severe water erosion in the study basin. The latter covers the center of the basin and its upper and lower sides. This formation is characterized by a dense back cover, dense water areas, and gully erosion (Shit and Maity 2012). Erosion and water problems also affect the lower part of the rock cover.

4.1.2 Soil properties

Soil quality in any area affects soil degradation. Land and land degradation are inseparable; Physical properties of the soil, such as compactness, hardness, permeability and density, determine the properties of the soil (Bready and Well 2005). High and low bulk density soils decompose differently. Soil texture differs from other characteristics of soil. The final soil structure determines the properties of the land (Askari et al. 2013).

The coarse-grained soil (mostly sandy loam) in the upper part of the Shilabati Basin has the characteristics of low humus content, high silica content and low water holding capacity (Figure 2.b). All these factors reduce soil fertility. The red soils in the rolling hills and mountains in the middle of the basin have high iron content, many leaching processes, low pH and low water holding capacity, resulting in soil degradation. The growth of streams and valleys in this soil causes a great loss of nutrients. (Shit et al., 2015). The high clay content in the lower part of the basin increases the water retention capacity, causing indirect floods. Due to underdevelopment, a large part of the basin is broken.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Typic Haplaquepts
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Loamy snad-Sandy clay loam
Sandy loam-Sandy clay loam
Sandy loam-Clay loam
Streams
Contour
Kilometers
c
Legend
Relief(Meter)
<50
50 - 100
100 - 150
150 - 200
>200
Streams
Contour
Kilometers
d
Legend
Slope(Degree)
<2
2 - 4
4 - 6
6 - 8
8 - 10
10 - 20
20 - 30
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Streams
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e
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Physiography
Flood Plain
Low Lands
Lower Alluvial Plain
Upper Undulating Alluvial Plain
Dissected Plateau
Badland
Dissected Highland
Gently sloping Upland
Creests of Undulating Plateau
Residual Hillocks And Mountains
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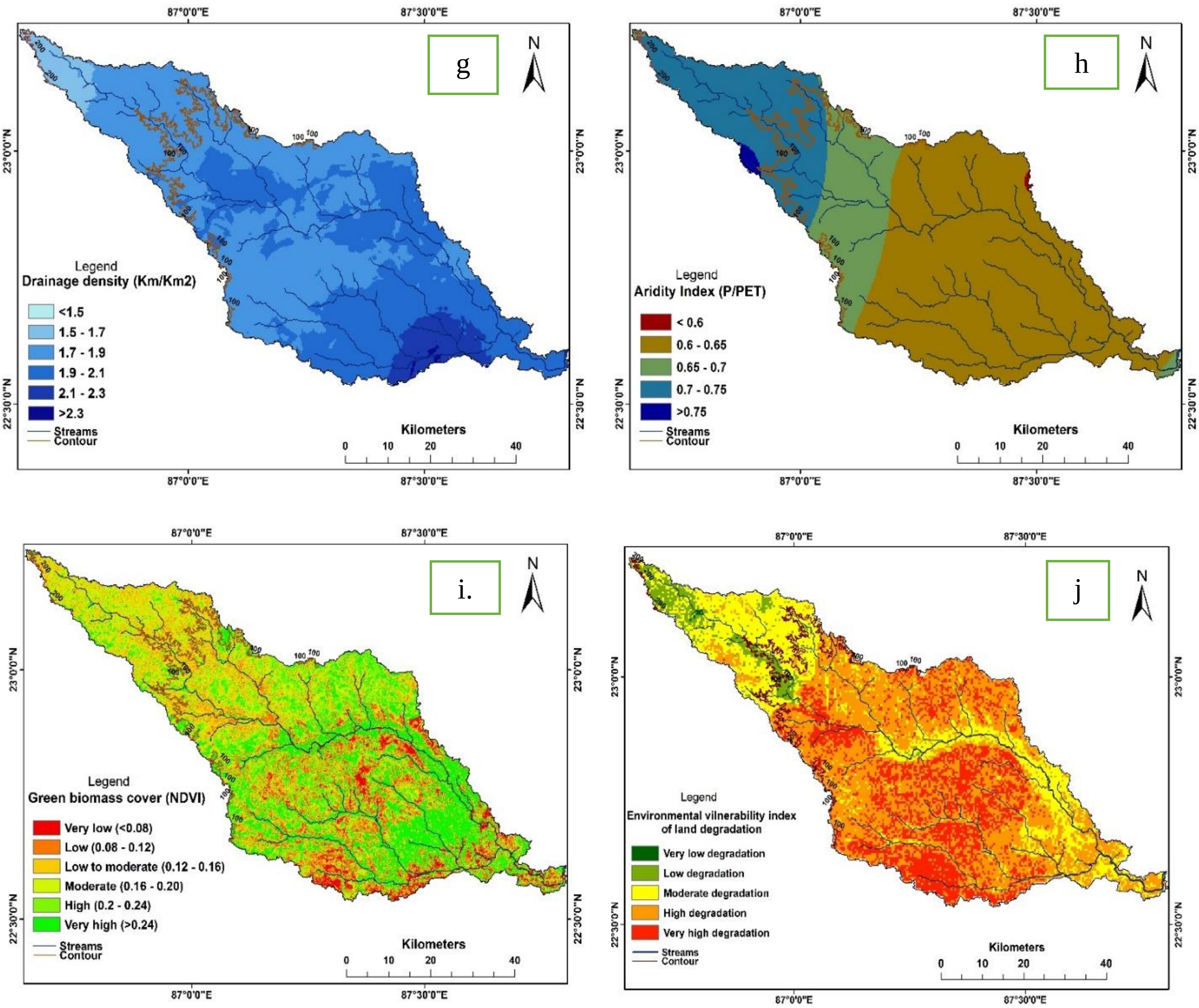

Figure 2: Physical characteristics and parameters of land degradation in the Shilabati River Basin: a. Geological structure, b. Soil properties, c. Relief features, d. Slope formation, e. Land features, f. Terrain changes, g. Water density, h. Drying (P/PET), i. Green biomass cover, j. Environmental vulnerability index.

4.1.3 Relief characteristics

Land degradation is determined by the characteristics of the relief or relief of an area. High altitudes (>600m), represented by high altitudes, create problems with earthquakes, avalanches, glacier hazards, and debris flows in mountain ranges worldwide (Myint and Thinley 2006). In areas where the slope is high, the slope becomes larger and the soil cannot grow normally. Construction differences are also affected by the type of salvage (Norbu et al. 2003).

A large part of the high-altitude area (> 200 m) of the Shilabati Basin covers the upper part of the basin (Figure 2.c). The region is characterized by an undulating terrain consisting of gently sloping hills and gabled hills. All these qualities reduce land productivity. Undulating, moderate terrains (>100 m) can also be found in the middle of the basin. This lake is dominated by anatomical topographic features on the hillside. Land development is prevented on the edge of the broken plateau (Shit and Maity 2012). Land degradation occurs due to water accumulation in the low water level (<50 m) part of the basin.

4.1.4 Slope Formations

The characteristics of the slope of each site determine the stability of the material and do not directly characterize soil degradation. The stability of the product is low on inclined surfaces (>30°). This situation causes all products exposed to degradation in the soil to become unstable. Too much slope hinders construction activities. The Central and Lesser Himalayas face these challenges (Myint and Thinley 2006). Most degradation processes in the Himalayan region are due to slope instability (Naz and Romshoo 2012).

The northern part of the Shilabati Basin has a high slope (> 8°), resulting in intense soil erosion and low soil moisture (Figure 2.d). The grassy slopes around the gables and roofs are not suitable for the development of mature soil in the upper part of the basin. The high altitude on the right side of the basin increases the potential for soil erosion throughout the basin. Stream and gully structures are important on the slope on the right bank of the Shilabati River (Shit and Maity 2012). The fact that the basin slope is too low (<2°) causes problems with dam construction.

4.1.5 Topographic Features

The topographic features of a region define the characteristics of the country. The presence of mountain valleys and swamps in mountainous regions prevents the development of good lands. Mountain earthquakes, glacial avalanches, and floods are common in the Himalayas or other mountainous regions (Rashid et al., 2011). Since plateau topographic features have a more sloping surface, they are not suitable for the soil profile. As the slope becomes steeper, the erosion capacity of the river increases, resulting in large-scale erosion. Foothills of the mountain landscape are also affected by debris flows associated with soil degradation. landslides (Norbu et al. 2003).

The undulating topography of the upper part of the Shilabati Basin is due to mountains, remnant hills, gently sloping hills and ridges (Figure 2.e). The collapse of the landscape and occasional dumping in the middle of the basin caused the land to decrease. Laterite land cover formed at the interface between rivers (Gulati and Rai 2014). There are many streams and grooves formed due to water erosion in the region. Higher undulating alluvial plains form the next thick layer. Floods and low-lying areas of the basin also have an impact on the climate of land degradation.

4.1.6 Groundwater Fluctuations

The presence of groundwater at high water levels is important for soil formation and soil moisture. Reasons for the decline in groundwater include imbalance of recharge and extraction, diversion of groundwater recharge, and withdrawal of large amounts of groundwater. All these changes reduce soil fertility (Nag and Ghosh 2013). Groundwater is the main source for soil moisture. Decreasing groundwater levels can promote soil drying, which can lead to soil degradation (Cosby et al., 2016). 1984). Groundwater is essential for agriculture in arid and semi-arid regions around the world. As land elevation increases, crop density increases. Many people live on fertile land. The water table has decreased due to a two- and three-fold increase in water for crops. On the other hand, the decrease in precipitation also prevents the renewal of groundwater. The presence of very deep aquifers in the basin or very high groundwater levels (> 6.5 mbgl) below the water table poses a serious threat (Figure: 2.f). Intensive agriculture in the lower reaches of the basin has increased demand and reduced groundwater levels. Groundwater in the intensive agricultural areas of the basin (lower column) continues to decline, leading to serious land degradation. Groundwater availability in the central region of the basin is moderate (5.7-6.1 mbgl). This is attributed to average agricultural production and low use of groundwater. Groundwater is abundant in the upper zone (<5.7 mbgl). Agricultural effort is low and forest land cover is high.

4.1.7 Drainage density

The characteristics of water flow in many regions directly or indirectly influence the soil degradation process. Drainage determines the slope, accumulation and erosion characteristics of the area. Rivers in every region reflect every topographic and geological environment. Flow frequency, intensity, profile and length are key features that control the erosion level of each watershed (Frankl et al., 2013). Different representatives also depend on the characteristics of the basin, such as basin slope, form, and size (Ali and Iqbal 2015). Against the crystalline backdrop of the coastal plateau, streams appear as the first streams continue to take their place. Over time, these streams turned into valleys and canyons, turning the region into a barren land (Shit and Maity 2012).

In the Shilabati Basin, the middle and lower interfluvial regions present high-water density (> 2.3 km/km2) (Fig. 2.g). The high slope of the Shilabati River, its thick wall and the constant washing of its right side are the main reasons for so much water. This is the storage area most affected by stream erosion in the basin. In most of the middle and upper parts, the water speed is moderate (1.5-2 km/km2). Reasons include poor soil permeability and low vegetation cover. The density of the upper part is low (<1.5 km/km2). Although the region has a wavy plateau, the main reason for this is hard rock formations.

4.1.8 Aridity conditions

The characteristics of each region (temperature, precipitation, sunlight, day length, wind direction and humidity) determine soil quality. Precipitation has a great impact on plant reproduction. The variability and extreme nature of rainfall can lead to soil erosion and soil degradation. In tropical regions, the intensity, frequency and total amount of rainfall have significant effects on soil erosion (Wessels et al. 2007). Precipitation and temperature determine the water balance in a region. The drought status of a region is determined by the characteristics of evapotranspiration. The precipitation/potential evaporation ratio (P/PET) is frequently used by climatologists to measure water balance (Thornthwaite 1948).

Shilabati Basin has humid characteristics such as low aridity and high P/PET ratio (> 0.7) in the upper part (Figure 2.h). This is due to the dense forest which causes rainfall. The drought level in the region is moderate.

Recent deforestation and the resulting expansion of agricultural land increases the risk of drought. The middle and lower parts of the Shilabati Basin show mild drought with low P/PET ratio (<0.65). The region still faces climate challenges despite its proximity to the Bay of Bengal, which provides a constant source of moisture and storms. The main cause of rainfall loss is the expansion of forest areas due to intensive farming and agricultural expansion. All these problems ultimately lead to the danger of land degradation.

4.1.9 Green Biomass Cover

External variation in land degradation is not good for land that is already covered with green biomass. Therefore, green cover should be less susceptible to degradation. Soil decomposition may occur in open areas due to direct rainfall. Direct sunlight reduces soil moisture and opens soil damage, causing soil erosion. Humus content is higher in soils covered with green biomass. Green biomass increases productivity by acting as aggregate for soil compaction (Kakembo 2001). This is how land is degraded in the open. From a global perspective, lands covered with green biomass have advantages such as low soil erosion, high organic content, good structure, high soil moisture and soil macro- and micronutrient concentrations. This is due to ongoing deforestation and agricultural expansion. Due to the lack of vegetation, the land is susceptible to water erosion from streams and gullies. Vegetation is only in the upper zone. The area is rocky, barren and unsuitable for growing plants. The lower half of the basin has more vegetation due to intensive agriculture (NDVI > 0.24). Soil erosion is a common occurrence during different agricultural activities.

4.2 Environmental Sensitivity Index to Land Degradation

The environmental vulnerability of Shilabati Basin to land degradation is obtained by dividing by various body weights. This shows that the inter-fluvial zone is a barrier to soil degradation (Figure 2.j). Deep ridge cover and wide streams and gullies are the main areas of erosion. The overflow of the middle and lower parts of the river is the zone of intermediate degradation. Deforestation and agricultural expansion play an important role here. Land degradation is quite low in the higher parts of the basin. High forest cover and low soil erosion help reduce land degradation.

5. Conclusion

Half of the world's land is degraded due to various natural and man-made causes. Land degradation mechanisms in tropical plateau areas differ from those found elsewhere in the world. The primary physiographic causes of land degradation are old geological formations, low-developed or heavily eroded soil cover, and dissected geomorphological traits. The main hydrological causes of tropical plateau land degradation are the ongoing decline of groundwater, increased rill and gully erosion, and increasing aridity. In contrast, increasing aridity (low P/PET ratio)-related salinization is the primary cause of tropical arid and semi-dry land degradation.

This study focuses on different physical or natural conditions and land degradation processes in the Srabati Basin, a marginal area of the highlands. Geological formations are examined from secondary data. Soil properties, surface water, drainage and vegetation conditions were obtained from DEM and other data sources. Groundwater and drought characteristics can be found through statistical analysis. Remote sensing and GIS tools play an important role in carrying out this study.

In the Shilabati Basin, the granite-gneiss-schist geology in the upper parts leads to more intrusion, more degradation and in-depth development. In contrast, downstream geology creates erosion problems. High relief and rugged topography lead to shallow soils, erosion, shallow water tables and high-water levels. Human activities in upland and muddy areas are also affected. The distribution of plateaus, undulating plateaus, bare hills, higher undulating plateaus, distributary plateaus, residual hills and mountains in the Shilabati Basin are problems in terms of productivity. Water depletion is caused by groundwater levels being very low in mountainous and mountainous areas, and they continue to fall in agricultural areas, resulting in large amounts of groundwater being withdrawn. High intensity and injection frequency for non-profit areas MPRAND for areas with high resistance. Decreased rainfall and increased pressure (low p/PET) can cause stress on water in the region. The area occupied by green biomass is constant. The total score of environmental vulnerability is higher in the middle and lower reaches of the river due to the large erosion of background water-related streams and gullies. Many processes of soil degradation have been investigated mainly using remote sensing and regional data.

As a result, there has been less field data collection, allowing for less calibration and validation. GIS and remote sensing techniques play crucial roles in the creation of factor maps. High-resolution data may improve the effectiveness of the output.

Finally, it is possible to conclude that soil conservation and land management are the two primary management challenges for protecting these sensitive land degradation areas. Mulching, terrace farming, and contour bunding are examples of soil management activities that should be concentrated on in the basin's steep upper reaches. Apply conservation tillage, use strips, avoid waterlogging and avoid sloppy growth. Improved biomass coverage in open and barren lands. Irrigation water use is kept to a minimum, and water conservation is achieved by pond and deep area building. Gully landfilling and increasing vegetation cover in gully land through deep root tree planting.

Conflict of interest: The author declares no conflict of interest.

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