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Susceptibility to Land Degradation in Haora Drainage Basin (HDB), Tripura, India

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Abstract: **Land degradation refers to lowering of the productive capacity of land due to natural processes and/or human activities. This paper aims to assess the degree of susceptibility to land degradation in Haora drainage basin (HDB) of Tripura, 2016. Susceptibility refers to vulnerability to land degradation. Land resources often suffer from various levels of degradation. Assessing susceptibility of land degradation emerges as an important field of study, essential for proper land management and planning. The degree of land degradation varies over space and time as per the causative factors of an area. In order to predict the susceptibility to land degradation in Haora drainage basin, a susceptibility map of land degradation has been prepared by taking the following causative factors of land degradation viz., land use land cover (LULC), vegetation cover (from NDVI), and slope aspect (in degree) of Haora drainage basin. Mapping land degradation susceptibility helps in the management of land resources, particularly from soil erosion.**

Keywords: **Land degradation, land use land cover (LULC), susceptibility, Haora drainage basin.**

I. INTRODUCTION

The land is one of the most vital components of the terrestrial ecosystem. Along with water and air, the land plays an important role in sustaining the life on the earth. The man has been utilizing the land and its resources from the time immemorial for various purposes and his well-being is closely linked to the quality of land in spite of the advancement in science and technology [1]. In course of his interaction with land, man has brought many changes and alterations in the land, most of which are detrimental to its resources. This has happened, especially after the application of advanced and innovative tools, technologies and strategies in agriculture, industries and construction works. It has led to the degradation of land, quantitatively and qualitatively. In recent decades, the problem of land degradation has become severe, complex and far spread in almost every part of the earth.

The total area of land on earth is about 30 percent of the planet's surface [2]. Out of this, only 11 percent of the world's land area had no limitation for agricultural use; on some 28 percent the climate is too dry, and on 10 percent it is too humid; on 23 percent the soil has critical chemical imbalances, and on 22 percent it is too shallow; while the remaining 6 percent is permanently frozen [3]. In addition, the land resource suffers from various forms of degradation, both from natural processes and human activities [4], and it is not limited to specific geographic zones, nor does it occur at a uniform rate [5].

Scientists have described the land degradation in different ways. Land degradation is defined as the loss of utility or potential utility or the reduction, loss or change of features or organisms which cannot be replaced [6]. It is the quantitative and qualitative deterioration of the elements of land such as soil, water, vegetation, etc beyond the natural replenishing capacity, resulting from excessive human pressure on these elements of land [7], it decreases in either or both the biological productivity and usefulness of particular place due to human interference [8], [9] and involves the temporary or permanent lowering of the productive capacity of land as a result of human actions [10].

Resources of the earth are subjected to alteration or change by human action. This change has two facets, beneficial or harmful which largely depend on knowledge and values possessed by humans who make the decision [11].

In Meghalaya, decrease in agricultural landholding, landfills, deforestation, overgrazing, the practice of *jhum* or shifting cultivation or slash-and-burn and scrap-and-burn method or bun cultivation, etc., along with the population growth and land use pressure have often caused an expansion of agricultural land use into less suitable regions and abandonment of traditional land use practices, etc., have increased soil erosion leading to declining of land productivity [12], [13], and hence causing land degradation [14].

During the monsoon period, Tripura receives frequent cyclones, hailstorms, and the flash floods, which caused damage to crops, vegetation, and settlement with their maximum impact on the erosion processes. The existing land use pattern like *jhuming* and agriculture on hill slopes accelerate soil erosion [15].

Different types, forms, the extent of land degradation are found in the world affecting the functioning and productivity of various ecosystems, particularly the fragile ecosystems like the tropical mountains. The fragile mountain ecosystems of Northeast India also suffer from land degradation. The Tripura hills are also an example of it. Within the Tripura hills, the HDB is one of the most degraded basins in terms of land and dependent population. In the present study, an attempt has been made to assess the degree of susceptibility to degradation in HDB.

II. STUDY AREA

The Haora river is a west-flowing river located in the western part of Tripura (Fig. 1). It is a sub-basin of the Titas river of Bangladesh which is again a sub-basin of the Meghna river. The HDB is located between 23°41'12.89"N to 23°56'44"N latitudes and extends from 91°33'38.77"E to 91°8'6.19"E longitude in West Tripura district towards the western part of the state. The river originates from western part of the Baramura hills in the eastern part of the basin then flows through east-west direction to drain into Titas river in Bangladesh. It flows through Chandrasadhubari to Agartala to meet Titas river in the western part of Bangladesh [16]. The total drainage covers an area of 435.53 sq. km. in Indian territory. The total length of the river in Tripura, India is 52.7 km.

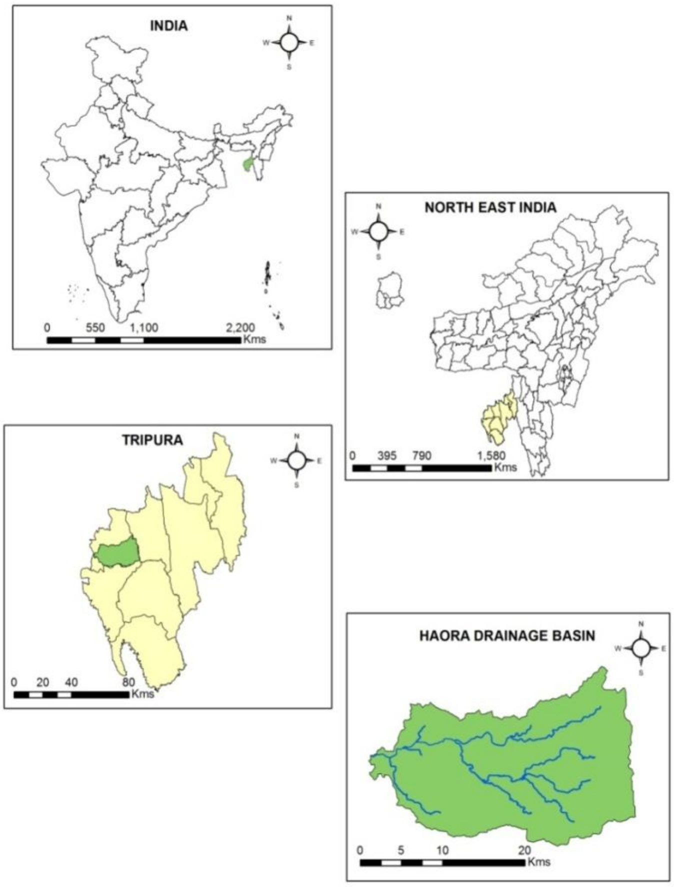


Fig 1: Location of Haora Drainage Basin, Tripura.

III. DATABASE AND METHODOLOGY

For the present study, both primary and secondary data has been collected. The database is presented in table format:

TABLE 1: DATABASE FOR ASSESSING THE SUSCEPTIBILITY TO LAND DEGRADATION IN HDB, TRIPURA.

Secondary Data	Basin Area	Basin area has been mapped from Digital Elevation Model (DEM) (2016) and Toposheets no: 79 M/5 and 79 M/6 and 79 M/9, at 1: 63,360 scale, surveyed in the year 1932-33 are also checked to see the changes in the study area.
	Vegetation Cover and LULC	Data has been acquired from Landsat satellite image 2016 satellite image from Landsat 8 Oli (operational land imager) band at scale 1: 30,000 has been used and validated from the field.
	Other information	State Statistical Department (Agartala), and from published and unpublished literature, Newspapers, Journals, Magazines, Websites, etc.
Primary Data	Ground Truthing	Images are verified through field survey (Dec. 2016) and GPS points have been taken.

In order to predict the degree of susceptibility to land degradation in HDB, Tripura (2016), various methods have been applied:

A. Land Use Land Cover Mapping:

The 1st level LULC mapping was done on the scale 1: 30,000, from Landsat 8 Oli (optical land image) band satellite image (2016). In image classification, any polygon having less than 2 sq. m. has been omitted due to a very small pixel at 1: 30,000 scale. Google image has been referred and GPS point has been taken for ground truthing.

B. Vegetation Cover:

Vegetation cover is calculated from Normalised Differential Vegetation Index (NDVI), it is as a ratio between measured reflectivity in the red and near-infrared (NIR) portions of the electromagnetic spectrum. These two spectral bands are chosen because they are most affected by the absorption of chlorophyll in leafy green vegetation and by the density of green vegetation on the surface, where the contrast for vegetation is maximum in red and NIR bands [17]. NDVI (Eq. 1) has been calculated using band 3 (red) and band 4 (near infrared) values [18].

$$NDVI = \frac{\rho NIR - \rho Red}{\rho NIR + \rho Red}, \qquad \text{Eq. (1)}$$

Where ρNIR is surface spectral reflectance in the NIR band and ρRed is surface spectral reflectance in the infrared band. NDVI assumes values from -1 to +1, with the highest values attributed to areas with greater vegetation [19].

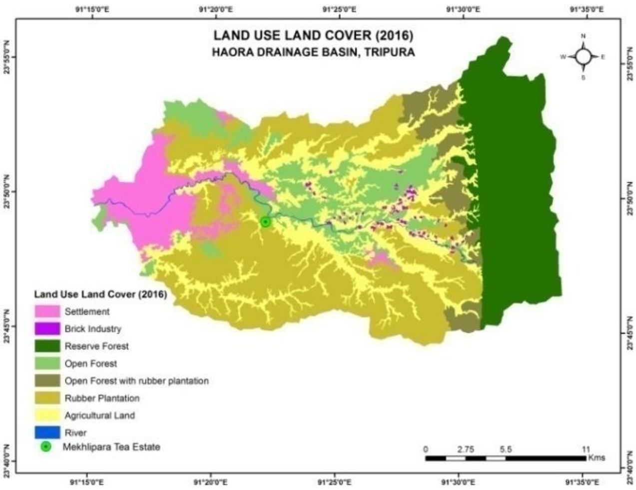
C. Delineation of the basin and slope degree:

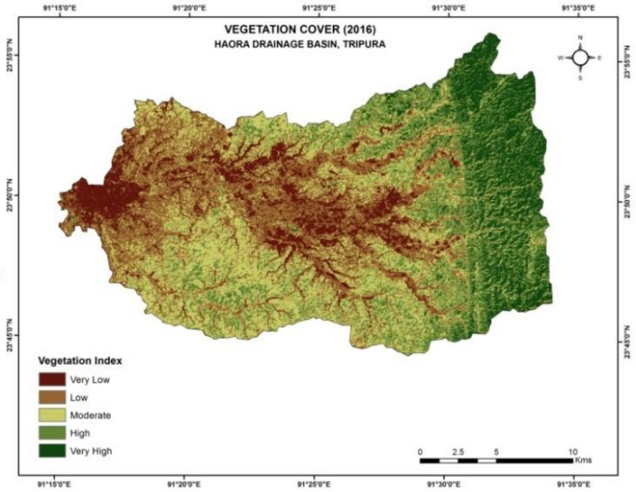
Boundary of HDB has been delineated from Digital Elevation Model (DEM) (2016). A slope aspect map has been prepared from DEM. Satellite imageries have been selected taking care of the seasonal variation and cloud-free status.

D. Assessment of Scceptibility to Land Degradation:

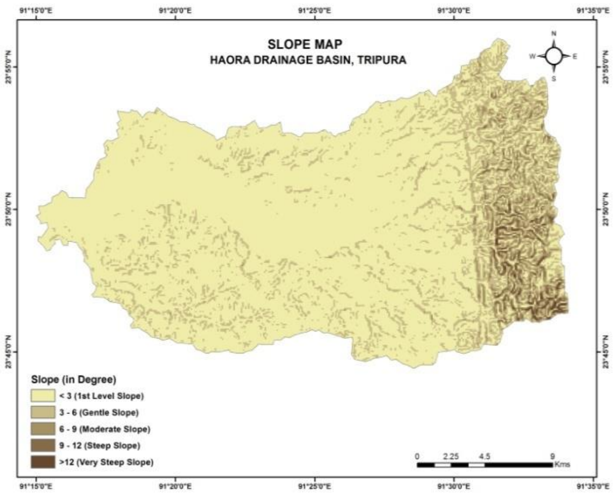
The severity of land degradation rating of its diagnostic/causative factors used in land degradation assessment in semi-arid and arid zones along the Great Wall of China [20], has been adopted and modified based on the suitability of the study area. Therefore, to assess the susceptibility to land degradation in HDB, a susceptibility map has been prepared taking the following causative factors, viz., 1. Land use land cover (LULC), 2. Vegetation cover (from NDVI), and 3. Slope aspect in degree (Fig. 2). Methods of land degradation susceptibility assessment are as follows:

i. Weightage has been given to the 11 categories of LULC (2016), which rates from 1 to 10, out of scale 1-10 (TABLE 2).





A. LULC, 2016 **B. Vegetation cover, 2016**



C. Slope map.

Fig 2: Causative factors (A, B and C) of land degradation in HDB, Tripura (2016).

TABLE 2: WEIGHTAGE OF LULC FACTOR CAUSING LAND DEGRADATION.

LULC Category	Weightage
Brick kiln	10
Deforestation	9
Shifting cultivation/*Jhum*	9
Fallow land	8
Agricultural land	7
Open forest	6
Open forest with rubber plantation	5
Rubber plantation	4
River	3
Settlement	2
Forest cover	1

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Vegetation cover is rated with attention to local rainfall. Thick vegetation cover has been observed in the eastern part of the basin, this area has higher rainfall than the western part of the basin. Every 5 categories of vegetation cover and slope aspect (in degree) has been given weightage from 1 to 5 out of scale 1-5 (TABLE 3). In the case of vegetation cover, lower categories suggest a higher susceptibility to land degradation and higher vegetation cover suggest lower susceptibility to land degradation. It is however different in the case of slope, as the slope with a higher degree has a higher potentiality to erode soil. Therefore, slope with lower degrees suggest lesser susceptibility to land degradation while a higher slope degrees suggest higher susceptibility to land degradation.

TABLE 3: WEIGHTAGE OF VEGETATION COVER AND SLOPE FACTORS CAUSING LAND DEGRADATION.

Vegetation Cover	Weightage	Slope in Degree (°)	Weightage
Very Low	5	First level slope (<3°)	1
Low	4	Gentle slope (3°-6°)	2
Moderate	3	Moderate slope (6°-9°)	3
High	2	Steep slope (9°-12°)	4
Very High	1	Very steep slope (>12°)	5

ii. Again, every rated layer of 3 causative factors of land degradation has been given weightage. LULC has been given a weightage of 45 percent because changes in LULC directly impacts soil erosion. The weightage given to vegetation cover is 30 percent as there is vegetation cover which checks soil erosion. The slope has been given a weightage of 25 percent as the degree of slope impacts the rate of land degradation. Consequently out of 100 percent all 3 factors have been given a weightage and this has been integrated into the GIS environment to evaluate the susceptibility of land degradation for the year 2016. This susceptibility to land degradation ratings suggests the degree of soil loss/erosion.

IV. RESULT AND DISCUSSION

The susceptibility to land degradation in the year 2016 can be categorised into 5 classes, viz., very low, low, moderate, high and very high categories (TABLE 4, Fig. 3 and Fig. 4), it indicates the degree of susceptibility to land degradation. The area under very low susceptibility to land degradation reports about 25.04 sq. km. accounting to 5.75 percent share of the basin area. These areas are associated with big settlement areas having very low vegetation cover with a first level slope (<3°) to the gentle slope (3°-6°). These areas are observed in the western part (Agartala and adjoining areas of Chandrapur and Ranirbazar are located here) and in a small patch in the southern part of the basin (Khumwlwng, TTAADC headquarter is located here).

The area under low susceptibility to land degradation covers about 83.75 sq. km. area or 19.23 percent share of the total basin area. These areas are seen in Baramura hills in the eastern part of the basin where the slope degree ranges from the moderate (6°-9°) to very steep slope (>12°) but the presence of very high vegetation cover (Baramura reserve forest) check the degree of susceptibility. The western part of the basin has low susceptibility in the peripheries of settlement areas and it is also seen in small patches in northern and southern part of the basin. These areas are under agricultural land located in low to moderate vegetation cover (rubber plantation) with the first level (<3°) to gentle (3°-6°) slope.

Moderate susceptibility to land degradation has a major share with 243.08 sq. km. area, accounting for 55.81 percent share of the basin. It is seen in all over the basin except in western part of the basin. In northern, south-western, south-eastern parts of the basin, the moderate susceptibility areas are seen in the areas of rubber plantation with moderate to high vegetation cover and in the first level (<3°) to moderate (6°-9°) slope. In the north-western part of the basin, it is seen in the areas of low to moderate vegetation cover (open forest) with the level slope (<3°). In the central part of the basin, it is located in the areas of low to moderate vegetation cover (mainly open forest) of the first level slope (<3°) area.

High susceptibility of land degradation area covers around 83.02 sq. km. area, which is 19.06 percent share of the total basin area. These areas are observed in central, southern, south-western and south-eastern part of the basin in agricultural land located nearby river banks with very low to low vegetation cover having the first level slope (<3°). In the north-eastern part of the basin, the high susceptibility areas are seen in the agricultural land in *lungas* (valleys) with very low to low vegetation cover and the first level slope (<3°). High susceptibility areas are also seen near the western foothills of Baramura hills located in the east, with moderate to high vegetation cover (open forest with rubber plantation) at steep (9°-12°) to very steep (>12°) slope area.

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Very high levels of susceptibility to land degradation has a very negligible area, it is 0.64 sq. km. area, which is 0.15 percent of the total basin area. These areas are found in a spot in isolated places. In central, central-eastern part of the basin, it is located in the brick field areas having brick kilns with very low vegetation cover in the first level slope (<3°) areas. In the north-eastern part of the basin, it is seen in the areas of agricultural land and very low vegetation cover (open forest) areas with the first level (<3°) to the gentle slope (3°-6°).

TABLE 4: DEGREE OD SUSCEPTIBILITY TO LAND DEGRADATION (2016) HDB, TRIPURA.

Degree of susceptibility to land degradation	Area (in sq. km.)	Share of the area (in %) to the total basin area
Very low	25.04	5.75
Low	83.75	19.23
Moderate	243.08	55.81
High	83.02	19.06
Very high	0.64	0.15
Total area	435.53	100.00

Source: Extracted by the author from susceptibility to land degradation map.

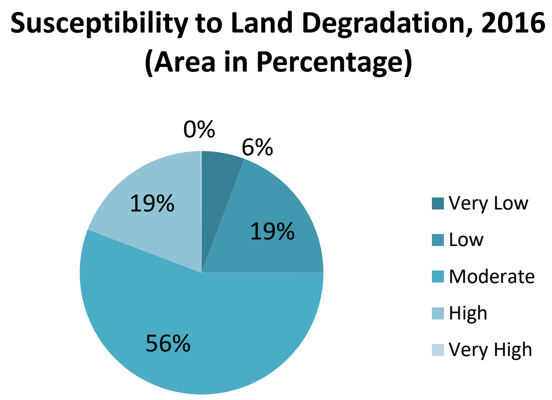

Fig 3: Susceptibility to Land Degradation (2016), HDB, Tripura.

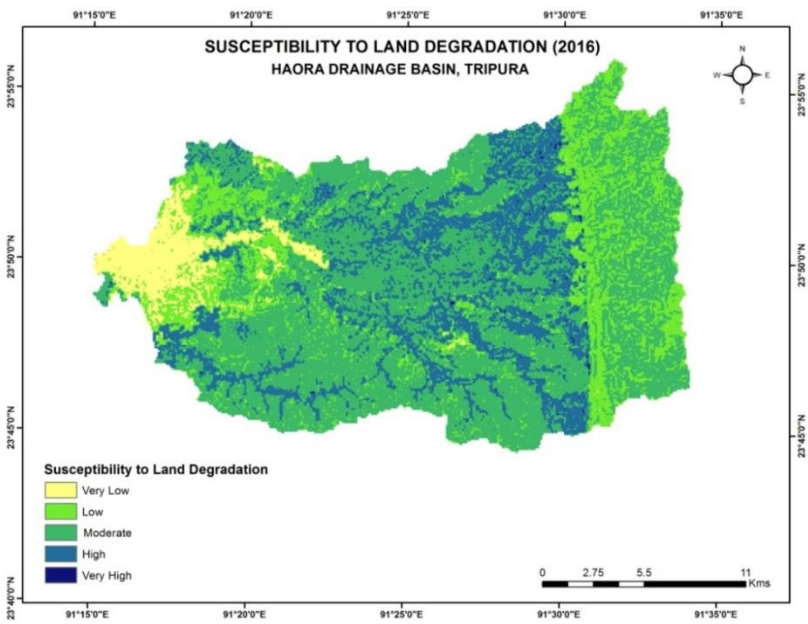

Fig 4: Susceptibility to Land Degradation (2016), HDB, Tripura.

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V. CONCLUSION

Therefore the present study on the susceptibility to land degradation in Haora drainage basin of Tripura (2016) shows the basin area is susceptible to various categories of land degradation, viz., very low, low, moderate, high and very high classes. These categories indicate the degrees of susceptibility. The present study also revealed that, more than half of the basin area (55.81 percent share of the total basin the area) has a moderate degree of susceptibility to land degradation. The moderate to very high types of susceptibility to land degradation needs to be checked as the area is dominated by rural land use and most of the farmers and agricultural labourers living in this area are directly dependent on land, as a result land degradation impacts on the livelihoods of the people here. Consequently, any human developmental activities here needs to maintain this level of land degradation as further land degradation here will adversely affect agriculture which is the mainstay of the people here.

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