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MAJOR CAUSES OF SOIL DEGRADATION IN HAORA DRAINAGE BASIN, TRIPURA, INDIA

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ABSTRACT

Soil is defined as "the portion of the earth's crust in which land plants can grow, if water and temperature are adequate, at least the minimum nutrients are available, and toxic substances are in low concentration" (Miller and Donahue, 1992). Soil resource is under increasing threat due to increasing complexities of human activities rendering this resource to be exhausted in qualitatively and quantitatively through soil degradation. Both human and natural factors are responsible for the causes of soil degradation. This paper aims to assess the major causes of soil degradation in Haora drainage basin of Tripura. In Haora drainage basin several major causative factors are identified from field study in 2016. Keeping 2016 as base year, previous two decades viz. 1996 and 2006 has been studied as well to have the vivid idea of the causative factors of soil degradation. Heavy rainfall, decreasing vegetation cover, population growth, change in agricultural land area, *Jhum* or shifting cultivation, introduction of plantation crops and brick kilns are the major causes of soil degradation in the study area.

Keywords: Soil degradation, land use land cover (LULC), vegetation cover, Haora drainage basin

1. INTRODUCTION

The problem of soil degradation is critical though Haora drainage basin at present reports mainly low to medium soil degradation in rural areas, it becomes essential to create awareness so that soil degradation can be maintained at this level or checked in small areas reporting high to very high category of soil degradation. It thus becomes imperative to know the causative factors of soil degradation in order to implement proper land/soil management.

2. LITERATURE REVIEW

ISSN: 2455-8834

Volume:03, Issue:08 "August 2018"

Soil erosion is a natural process but human activities accelerate the natural process if proper management is not taken. Soil is under increasing threat from a wide range of human activities that are undermining its long term availability and viability. The Causes of soil degradation are both natural and human-induced. Natural causes include earthquakes, tsunamis, droughts, avalanches, landslides, volcanic eruptions, floods, tornadoes, and wildfires. Human-induced soil degradation are caused due land clearing and deforestation, inappropriate agricultural practices, urban sprawl, and commercial/industrial development, etc. (Bhattacharyya *et. al.*, 2015).

According to Turner *et al*. (1994), the two widely used terms for denoting transformation of land from natural into managed ecosystem are: land use and land cover. Information on land use and land cover is useful for planning, assessing the impact on soil degradation (Lal *et al*., 2004). In the less economically privileged parts, 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. This change in land use cause land degradation (Körner *et al*., 2006).

Jhum or slash-and-burn cultivation is a primitive method of agriculture and considered as one of the major causes of land/soil degradation in the tropical hill ecosystem. The loss is immense in *jhum* cultivation compared to its output. According to Mazumder (1984) during the monsoon period, Tripura receives frequent cyclones, hailstorms and the flash floods, which cause 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

In the present study an attempt has been made to assess both natural and human causes responsible for soil degradation in Haora drainage basin.

3. STUDY AREA

The Haora River is a west flowing river located in the western part of Tripura (figure 1). It is a sub-basin of the Titas River of Bangladesh which is again a sub-basin of the Meghna River. The Haora River Basin 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 western part of the state. The river originates from Western part of Baramura hill range 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 western part of Bangladesh (De, 2012). 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.

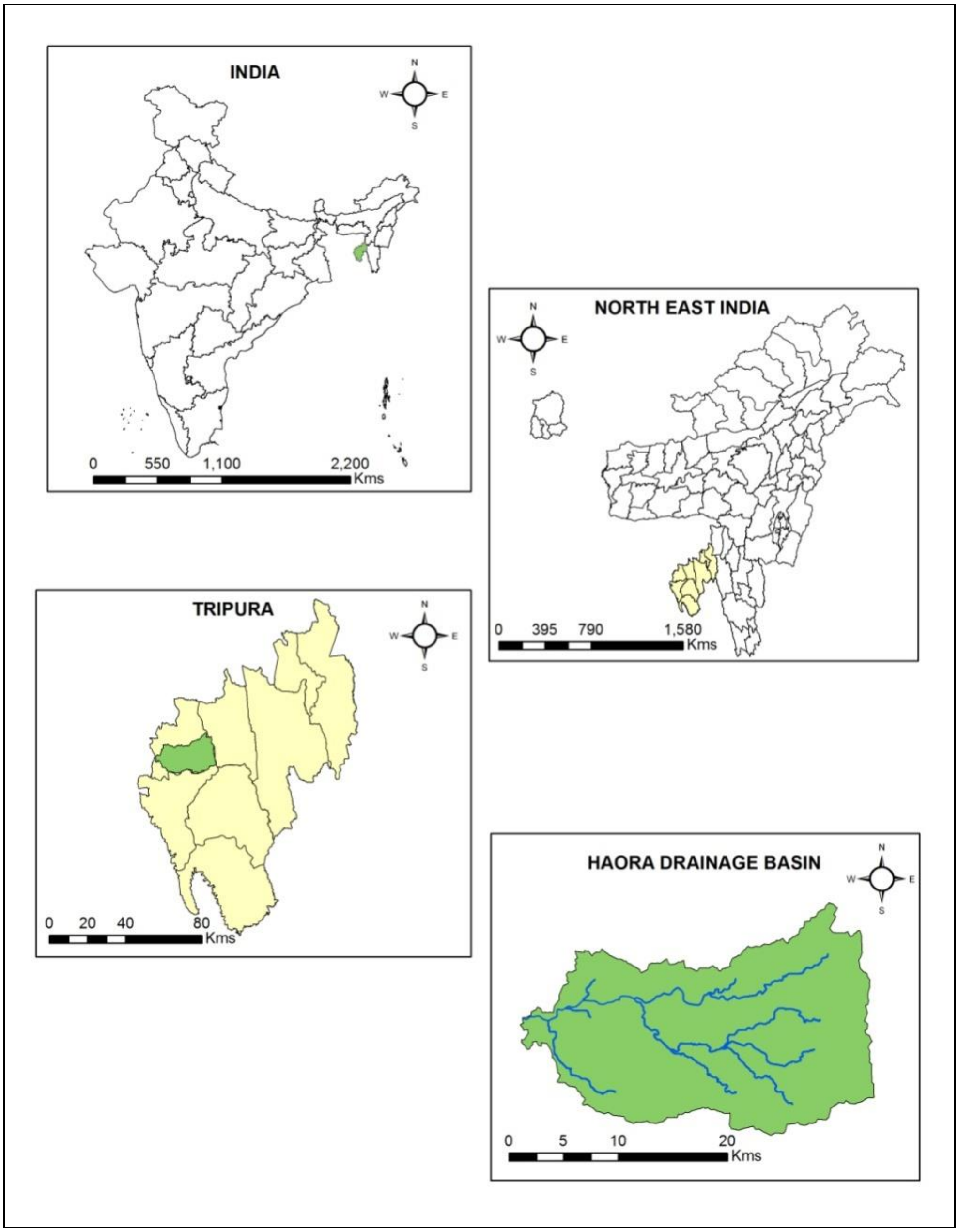

Figure 1: Location of Haora Drainage Basin, Tripura.

4. DATABASE AND METHODOLOGY

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

ISSN: 2455-8834

Volume:03, Issue:08 "August 2018"

Table 1: Database for assessing the major causes of soil degradation in Haora drainage basin of Tripura.

Secondary Data	Basin Area	Basin area is 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 time series satellite images (1996, 2006 and 2016). Landsat 7-1996, 2006 (ETM+) and 2016 satellite image from Landsat 8 Oli (operational land imager) band at scale 1: 30,000 has been used and validated from the field.
	Local rainfall data	Meteorological Department (IMD), Agartala.
	Population data	Census Reports for population data, Block Developmental Office (Mandai, Jirania, Belbari, Old Agartala, Dukli).
	Other information	State Statistical Department (Agartala), and from published and unpublished literatures, Newspapers, Journals, Magazines, Websites, etc.
Primary Data	Ground Truthing	Images are verified through field survey (Dec., 2016) GPS points have been taken.

To identify the major causes of soil degradation operating in the study some major parameters has been studied-

i. Land Use Land Cover Mapping: Land use land cover (LULC) data has been extracted from LULC maps generated from Landsat images. The 1st level LULC mapping has been done on the scale 1: 30, 000, data has been acquired from Landsat time series satellite images (1996, 2006 and 2016). Google image has been referred and GPS point has been taken for ground truthing. Data on agriculture, plantation, jhum or shifting cultivation, brick kilns has been extracted from this 1st level classification of LULC map (1996-2016).

ii. Vegetation Cover: Vegetation cover data has been extracted from Normalised Differential Vegetation Index (NDVI), it is calculated 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. The contrast for vegetation is maximum in red and NIR bands (Khire and Agarwadkar, 2014). NDVI (Eq. 1) has been calculated using band 3 (red) and band 4 (near infrared) values (Tucker, 1979).

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

Where, ρNIR is surface spectral reflectance in the near-infrared 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 (Durigon *et. al*., 2014).

5. DISCUSSION AND ANALYSIS OF STUDY

Some major causative factors of soil degradation in the Haora drainage basin area can be divided into:

(i) Natural Causes, and
(ii) Human-induced Causes

5.1 Natural Causes

5.1.1 Heavy Rainfall

Heavy downpour of torrential rainfall and run-off water are responsible for sheet, rill and gully erosion in fragile ecosystem of Tripura. During rainfall the top fertile soil from hills are washed away, sometimes even losing productive agricultural lands in the higher slope. Since Agartala Meteorological station is located nearest to the basin, rainfall data of this station has been considered for present study.

Normal Rainfall (in mm.) at Agartala Station (1996-2016) shows that the minimum normal rainfall is 1654.9 mm. in the year 2011 and maximum normal rainfall is recorded to be 2966.2 mm. in the year 2007 (table 2 and figure 2). The average rainfall from 1996 to 2016 is 2145.21 mm. Though the rainfall is recorded to be high in the basin the good cover management factor (moderate to very high vegetation accounting to 71.79% of total basin area in 2016) will check the rate of soil loss. Therefore the basin has lesser chance of experiencing higher soil loss.

ISSN: 2455-8834

Volume:03, Issue:08 "August 2018"

Table 2: Monthly Rainfall at Agartala Station (1996-2016)

(Rainfall in mm.)

Year	January	February	March	April	May	June	July	August	September	October	November	December	Normal
1996	0.0	6.0	85.4	92.6	430.4	416.9	310.5	165.0	206.3	305.0	0.0	0.0	2018.1
1997	10.3	17.2	55.7	108.3	170.9	504.7	735.7	246.9	433.8	94.1	20.3	22.3	2420.2
1998	34.1	11.9	56.4	255.7	421.8	123.1	592.3	278.6	113.0	63.6	107.9	0.0	2058.4
1999	0.0	0.0	27.0	0.0	359.8	241.4	596.3	551.8	406.2	324.4	0.0	0.0	2506.0
2000	12.0	20.1	111.4	234.5	537.6	264.6	116.1	332.0	112.6	218.8	0.6	0.0	1960.0
2001	0.0	66.6	12.6	63.5	481.9	638.6	176.8	285.0	241.6	314.7	52.7	0.0	2334.0
2002	11.5	0.2	117.5	184.4	373.1	507.0	485.7	295.4	154.9	77.2	157.1	0.0	2364.0
2003	0.0	4.9	114.1	169.6	359.4	681.8	244.3	147.5	211.1	106.2	0.0	43.3	2082.0
2004	7.9	11.7	3.5	384.3	138.0	659.8	450.6	231.2	460.9	151.7	0.0	0.0	2499.6
2005	2.8	11.6	159.1	108.9	353.9	133.1	309.0	326.3	236.5	179.0	0.0	0.7	1820.9
2006	0.1	0.0	0.0	136.5	536.3	444.5	168.8	293.3	210.8	112.2	3.7	0.0	1906.2
2007	0.0	45.5	7.0	458.6	306.3	637.5	786.5	207.8	173.2	226.9	116.9	0.0	2966.2
2008	51.4	12.8	68.1	34.2	272.3	167.2	378.4	362.4	74.9	261.6	0.0	0.0	1683.3
2009	0.0	0.0	0.0	70.4	399.3	477.7	506.8	313.3	431.0	186.6	18.0	0.0	2403.1
2010	0.0	0.0	75.7	218.1	671.6	494.7	314.7	266.5	320.3	232.7	0.0	53.6	2647.9
2011	0.2	0.6	49.9	55.2	359.4	329.9	231.1	361.3	203.4	63.9	0.0	0.0	1654.9
2012	7.2	1.2	2.0	242.1	176.5	292.8	352.8	337.0	211.4	62.9	39.2	0.0	1725.1
2013	0.0	9.2	25.2	132.6	695.3	396.6	137.5	162.6	217.5	190.3	0.0	0.0	1966.8
2014	0.0	7.7	2.0	140.3	261.7	483.6	145.0	380.4	192.5	93.9	0.0	0.0	1707.1
2015	2.6	31.0	14.0	441.6	253.6	400.0	699.8	387.3	110.2	73.4	0.0	1.4	2414.9
2016	1.2	27.5	80.8	162.7	512.7	191.3	271.2	233.5	163.2	91.9	172.3	2.4	1910.7

Source: IMD, Agartala.

ISSN: 2455-8834
Volume:03, Issue:08 "August 2018"

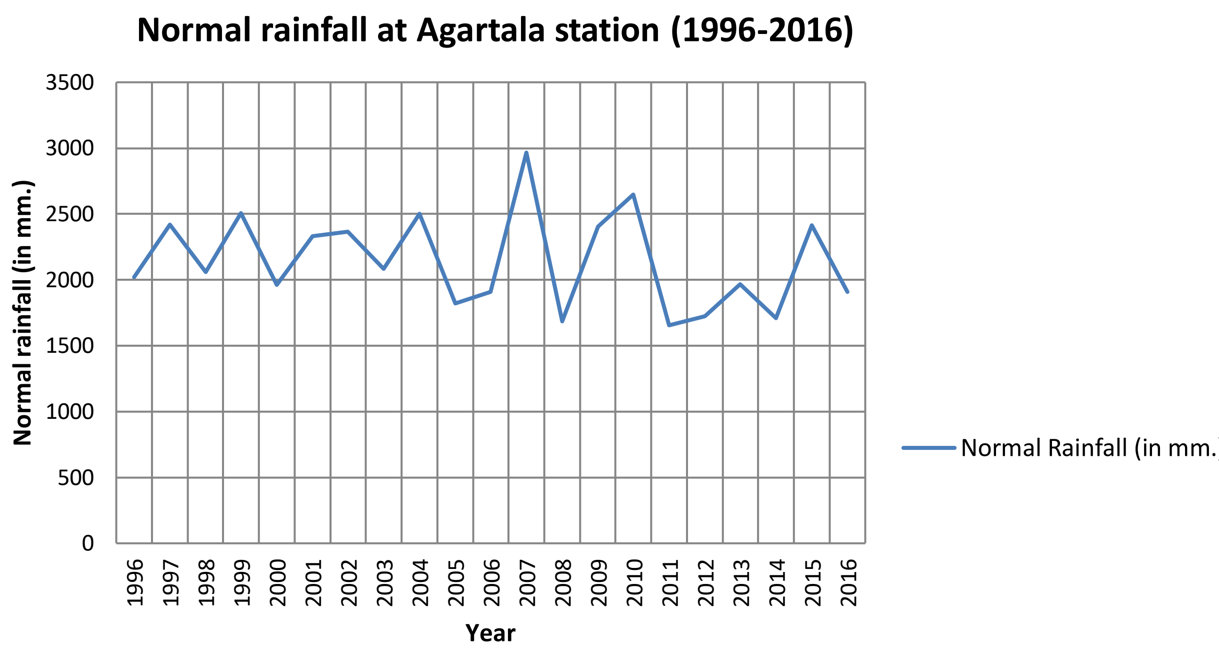

Figure 2: Normal Rainfall (in mm.) at Agartala Station (1996-2016).

5.1.2 Vegetation Cover:

Plants considered collectively, especially those found in a particular area or habitat (https://en.oxforddictionaries.com/definition/vegetation, accessed on 08.01.2018). Classifying and mapping vegetation type is important for mapping natural resources as vegetation affects all living beings and influences the global climate and territorial Carbon Cycle significantly (Sala *et, al.*, 2000, Xiao, *et. al.*, 2004). Natural Vegetation refers to a plant community that has been left undisturbed over a long time, so as to allow its individual species to adjust themselves to climate and soil conditions (en.oxforddictionaries.com, accessed on 01.01.2018). Increase in population and continuous demand in the amount of agricultural land has led to indiscriminate exploitation of natural forest and fragile land leading to soil organic matter and soil nutrient depletion which are among the major forms of soil degradation (Lemenih *et. al.*, 2005).

Das (Pan) 2011 highlighted that, about 72.73% (Forest Survey of India in 1991) of forest land in Tripura are suffering from degradation and vegetation cover/ forests is diminishing due to various anthropogenic disturbances mainly, Population growth due to both natural and immigration from Bangladesh, unauthorised tree felling and smuggling of forest produce, practice of shifting cultivation (*jhum*), Forest encroachments, etc.

ISSN: 2455-8834
Volume:03, Issue:08 "August 2018"

Data for decadal change in vegetation cover of the basin has been extracted from NDVI (1996-2016), according to which vegetation cover of Haora drainage basin can be categorized into 5 classes, from very low to very high classes (table 3).

Table 3: Vegetation Cover (VC) in Haora Drainage Basin (1996-2016).

Category	VC 1996		VC 2006		VC 2016	
	Area in Sq. km.	Share of Area (in %) to total area	Area in Sq.km.	Share of Area (in %) to total area	Area in Sq. km.	Share of Area (in %) to total area
Very Low	0.00	0.00	0.10	0.02	0.68	0.16
Low	0.03	0.01	0.20	0.05	122.19	28.06
Moderate	6.18	1.42	69.82	16.03	211.77	48.62
High	201.31	46.22	305.32	70.10	89.47	20.54
Very High	228.02	52.35	60.08	13.79	11.42	2.62
Total Area	435.53	100	435.53	100.00	435.53	100.00

Source: Extracted from NDVI of Haora Drainage Basin (1996-2016).

Very low category of vegetation cover is found to be absent in the year 1996, which increases to 0.10 sq. km. (0.02 %) of the basin area in 2006 to 0.68 sq. km. (0.16 %) of the basin area in the year 2016. Low category of vegetation cover in 1996 is 0.03 sq. km. which is 0.01% of the basin area has increases to 0.20 sq. km. accounting for 0.05% of the basin area in 2006, which increases to 122.19 sq. km. or 28.06% of the basin area in the year 2016. Moderate category of vegetation cover in 1996 is 6.18 sq. km. or 1.42% of the basin area which increases to 69.82 sq. km. or 16.03% of the basin area in 2006, this category has been observed to have doubled in the year 2016 i.e., 211.77 sq. km. or 48.62% share of the basin area. High vegetation cover in 1996 is 201.31 sq. km. or 46.22% of the basin area which increased to 305.32 sq. km. accounting to 70.10% share of the basin area in the year 2006. In 2016, this category of vegetation cover has tremendously decreases to 89.47 sq. km. or 20.54% of the basin area due to anthropogenic factor. Very high vegetation cover category also decreased from 228.02 sq. km. in 1996 decreases to 60.08 sq. km. in 2006, to 11.42 sq. km. in 2016 (table 3 and figure 3).

ISSN: 2455-8834

Volume:03, Issue:08 "August 2018"

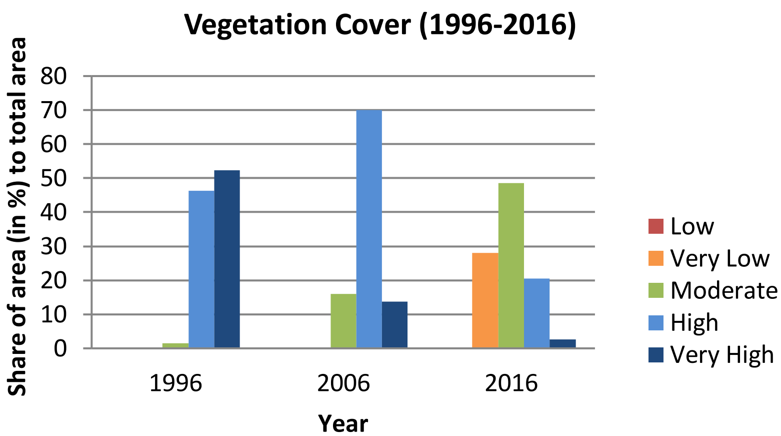

Figure 3: Vegetation Cover (VC) in Haora Drainage Basin (1996-2016), showing share of area (in %) to total area.

The increasing low and moderate vegetation and on the other hand decreasing trend in high and very high categories of vegetation cover indicates that open forest are increasing in this basin. However, the overall vegetation cover area is still high as compared to national forest cover 21.23% of geographical area (State of Forest Report, 2013). Expansion of agricultural land, plantation and settlement area for growing population in the basin is one of the factors leading to deforestation. Logging, collection of forest firewood and for the huge demand of firewood for brick kilns in the areas other causes of deforestation in Baramura hills.

5.2 Human-induced causes

5.2.1 Population Growth

Population change is considered as one of the most important factors causing land degradation. Population stagnation or decline can also be a cause of land degradation (Barrow, 1991). However it is also seen that in sensitive areas or with certain type of exploitation population need not be high to cause problems.

About 95.11% share of the Haora drainage basin is located in West Tripura district therefore, population of West Tripura district has been considered for the study of population growth of the basin. In west Tripura district, during the year1951-1961 has seen a rapid population growth. During this period huge influx of refugees to Tripura from East Bengal now Bangladesh was recorded (De, 2014). From the year 1961-1991 West Tripura District shows slow decadal population growth and from 1991-2001 onwards it shows decreasing trend. It indicates the West Tripura district population has steady growth rate. In future if the population growth is controlled

ISSN: 2455-8834

Volume:03, Issue:08 "August 2018"

at this level the further soil degradation could also be minimised. Comparison with the decadal growth of West Tripura District, Tripura and India shows there is a wide gap between the growth trend of West Tripura or Tripura with India (Table 4 and figure 4). West Tripura District/ Tripura have recorded lower than national growth rate since 2001 to the recent.

Table 4: Decadal Population Growth of Tripura and West Tripura District (1951-2011).

Year	Total Population of West Tripura District	Decadal Growth Rate of West Tripura District	Total Population of Tripura	Decadal Growth Rate of Tripura	Total Population of India	Decadal Growth Rate of India
1951	321775	-	639029	-	361088090	-
1961	571329	77.56	1142005	78.71	439234771	21.64
1971	747552	30.84	1556142	36.26	548159652	24.80
1981	976252	30.59	2053058	31.93	683329097	24.66
1991	1293861	32.53	2757205	34.30	846302688	23.85
2001	1532982	18.48	3199203	16.03	1028610328	21.54
2011	1729451	12.82	3671032	14.75	1210193422	17.65

Source: Population Census of India, (1901-2011).

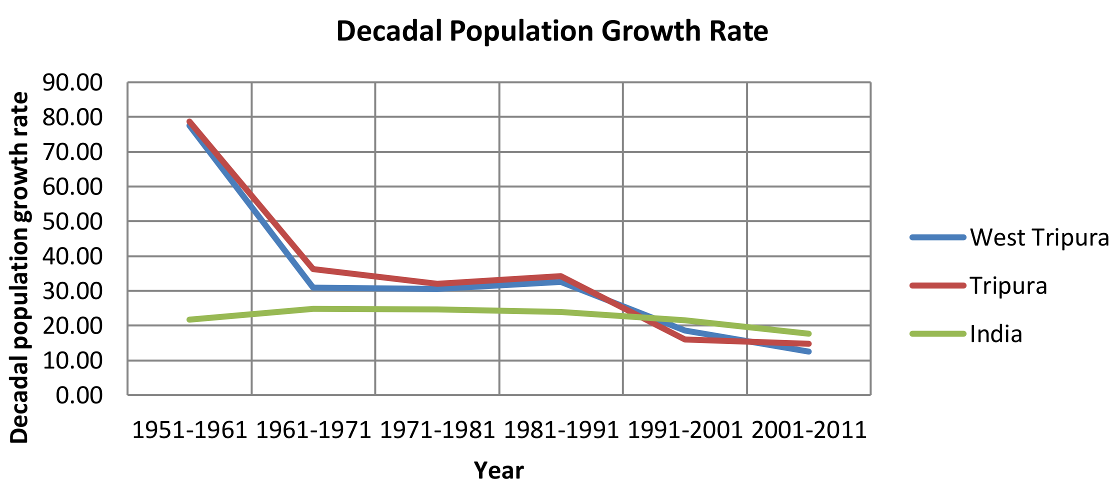

Figure 4: Population of Tripura (1901-2011).

5.2.2 Agricultural Land

The land which is primarily used for agricultural production, farming, production of food, fibre, other commercial and horticultural crops are included in this category. In the study area wet paddy is cultivated in plains and *lunga* or valley, rice also cultivated in hill/ *tilla* (shifting cultivation). The crops are cultivated both in summer and winter as kharif and rabi crops as

ISSN: 2455-8834

Volume:03, Issue:08 "August 2018"

subsistence type. Some river side agricultural land are cultivated triple crops as water table is narrow it can be irrigated easily, vegetables are also cultivated in this areas to meet the demands of growing population of nearby Agartala city and for the local markets. Fallow land is the agricultural land which is temporarily allowed to rest for replenishing the soil nutrients, for one or two season, but less than one year. The *lunga* lands are cultivated only once a year. Rice is the main crop cultivated throughout all 3 seasons, as khariff, rabi and pre-kharif. Pulses are grown during karif and rabi, potato is grown as rabi crops. Major horticultural crops are cauliflower, cabbage, tomato, brinjal, etc.

The agricultural activities are still subsistence type in the valleys and primitive types in the hills which has less chance to severely degrade soil resource. The Agricultural land area of the basin is shown in table 5. It shows agricultural land areas are decreasing from 20.30% of the basin in 1996 to 18.15% in 2016 as most of the agricultural lands are converted into other types of land use (table 6).

Table 5: LULC change in Haora drainage basin (1996-2016).

LULC Category	Area in 1996 (Area in sq. Km.)	Share of Area (in %) to total Area in 1996	Area in 2006 (Area in sq. Km.)	Share of Area (in %) to total Area in 2006	Area in 2016 (Area in sq. Km.)	Share of Area (in %) to total Area in 2016
Agricultural land	88.43	20.30	89.10	20.46	79.03	18.15
Fallow land	2.70	0.62	0.00	0.00	0.00	0.00
Brick industry/ kiln	0.00	0.00	1.57	0.36	2.36	0.54
Jhum	1.95	0.45	8.92	2.05	0.00	0.00
Forest cover	95.46	21.92	86.13	19.77	94.87	21.78
Open forest	188.87	43.36	204.92	47.05	50.20	11.53
Open forest with rubber plantation	0.00	0.00	0.00	0.00	23.40	5.37
Rubber Plantation	27.21	6.25	10.86	2.49	145.62	33.43
Deforestation	0.00	0.00	8.55	1.96	0.00	0.00
River	2.37	0.55	1.72	0.40	1.70	0.39
Settlement	28.54	6.55	23.76	5.46	38.35	8.81
Total area	435.53	100.00	435.53	100	435.53	100

Source: Extracted from 1st level classification of LULC map (1996-2016).

ISSN: 2455-8834

Volume:03, Issue:08 "August 2018"

Table 6: Change in agricultural area of Haora drainage basin (2006-2016).

Change	Area in sq. km.
Agricultural land to open forest with rubber plantation	4.64
Agricultural land to brick industry	0.55
Agricultural land to open forest	10.14
Agricultural land to reserve forest	1.12
Agricultural land to river	0.16
Agricultural land to rubber plantation	13.15
Agricultural land to settlement	3.21
Total	32.97

Source: Extracted from LULC change detection from 2006 (ETM+) and from Landsat 8 Oli band-2016 satellite image.

5.2.3 *Jhum*/ Shifting Cultivation

Shifting or *jhuming* cultivation is a type of agriculture practice by tribal population since the time immemorial of *tripuri* civilization. Traditionally, most of the tribal population of Tripura practised in the forest covered hill slopes of the state. Which yield barely enough output to the jhumias or shifting cultivators to survive for a few months in a year and they have to supplement their income by mainly working as wage labourers for the forest department or by collecting forest produce thus the Jhumia of Tripura are among the poorest of the poor in the state (Das Gupta, 2006). The people living in the Baramura hill practiced *jhum* in patches where mixed crops are grown. In the earlier days the cycle of shifting cultivation fallow used to be 15 to 20 years then it became 2 to 3 years (Tripura Infoway, 2018). Most shifting cultivation practices are subsistence level farming system having very low output/ input ratio compared to other farming systems/ methods.

Comparing the area of shifting cultivation with respect to 2003-04 (table 7), it is found that *jhum* areas are showing decreasing due to the most important and recent strategies adopted for *jhumia* rehabilitation in Tripura through rubber plantation providing *Jhumias* with a substantial income along with cash crops like pineapple and pepper which were grown with it (Das, *et al.*, 2012). *Jhum* area from1996-2016 shows that *jhumming* is decreasing (table 6). It is seen that *Jhum* land about 8.92 sq. km. areas of the basin in 2016 is converted to rubber plantation in reserve forest areas.

ISSN: 2455-8834

Volume:03, Issue:08 "August 2018"

Table 7: Shifting cultivation in Baramura-Deotamura (2003-04 to 2011-12)

Year	Area in sq.km.	% of reduction with respect to 2003-04
2003-2004	27.55	
2008-2009	8.94	67.55
2011-2012	12.68	53.97

Source: Das, et al., 2012.

5.2.4 Plantation

Rubber plantation is hugely cultivated in the study area, *tilla* land which was previously on shifting cultivation has been rehabilitated with rubber plantation as it has demand and more profitable. Other plantation like tea, areca nut, horticultural crops (lemon, banana, mixed fruits) are cultivated in a very small land holding which are hard to differentiate from rubber plantation as it is located near its peripheries. The horticultural crops are mainly cultivated by small farmers with the help from the Agriculture and Forest Department, Government of Tripura.

In Tripura, West Tripura district has the highest rubber plantation area with 176.2512 sq. km or 23.71% share of area to total area under rubber plantation accounting to 18.07 % share of area to TGA of West Tripura District (Table 8).

ISSN: 2455-8834

Volume:03, Issue:08 "August 2018"

Table 8: District-wise area and Production of Rubber in 2015-2016.

District	Immature Area (ha.)	Mature Area (ha.)	Total Area (ha.)	Total Area (Sq. Km.) under rubber plantation	Total Geographical Area (TGA)	Share of Area (in %) to Total Area of under Rubber Plantation	Share of Area (in %) to TGA of District	Production (MT)
West Tripura District	9769.12	7856	17625.12	176.2512	942.55	23.71	18.70	9772.86
Sepahijala District	10063.94	6782.01	16845.95	168.4595	1044.78	22.66	16.12	8436.82
Gomati District	3075.94	4340.08	7416.02	74.1602	1522.8	9.98	4.87	5399
South Tripura District	3575.68	11875.72	15451.4	154.514	1534.2	20.79	10.07	14773
Unakoti District	1104.76	1520.4	2625.16	26.2516	591.93	3.53	4.43	1891
North Tripura District	2924.68	4208.71	7133.39	71.3339	1444.5	9.60	4.94	5234
Dhalai District	2091.07	2138.77	4229.84	42.2984	2400	5.69	1.76	2660
Khowai District	1580.04	1428.03	3008.07	30.0807	1005.67	4.05	2.99	1776
Total	34185.23	40149.72	74334.95	743.3495	10486.43	100.00	7.09	49942.68

Source: Rubber Board of Tripura.

The rubber plantation in Haora drainage basin in the year 1996 is 27.21 sq. km. or 6.25 % of the basin area which decreases in the year 2016 with 10.86 sq. km. or 2.49% of basin area, again the areas of rubber plantation increases tremendously in the year 2016 with145.62 sq. km. or 33.43% areas of the basin (table 5). This increase in rubber plantation helps in controlling soil loss of the basin reducing severe to very severe types of soil degradation.

ISSN: 2455-8834

Volume:03, Issue:08 "August 2018"

5.2.5 Brick Kiln:

Haque (2011) have analysed various impacts of removal of top-soil from agricultural lands through the participant observation and interview method in Midnapur, Sadar Block, West Bengal. It has been analysed that the majority of respondents complaints about land turning to poor yield condition, declining fertility condition of land, for irrigation purpose these lands creates water logging for long time and also causes obstruction to the natural flow of irrigated water. This problem is not different in counterpart of Tripura particularly the study area.

Brick kiln constitutes a major part of the industrial economic activity at Jirania Sub division (Bera, 2016) located in the centre of Haora drainage basin in West Tripura district Mud is the source of making brick where the top soil in brick field is carried away making soil infertile (Jamatia, *et al.*, 2014) and suffers from agricultural land degradation (Bera, 2016). The brick kiln areas of the basin is shown in table 5. From the year 2006 to 2016 it has increased to 0.69 sq. km. areas of the basin. Brick fields are under 1.57 sq.km areas or of the basin in 2006 accounting to 46 nos. of kilns which has increased to 2.26 sq. km. (56 nos. of kilns) in 2016.

5.2 Conclusion

From the above discussion it is seen that both the physical and human factors are responsible for soil degradation. Normal rainfall is recorded high but the vegetation cover is also high (moderate to very high vegetation accounting to 71.79% of total basin area in 2016) as compared to national forest cover 21.23% of geographical area (State of Forest Report, 2013) and cover management (through rubber plantation) is quite good, so the soil loss is less in this basin. On the other hand, the population growth has been controlled and the *jhum* cultivation areas have been reduced through rehabilitation (mainly trough rubber plantation) so it does not impact much to cause severe type of land/soil degradation to this basin. The brick kilns areas or brick fields are the only causative factor responsible for severe to very severe type of soil degradation in this basin, needing attention from both government and public sector for controlling further land degradation.

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