

# Impact of Expansion of Bypass Road for Asian Highway Development Project (AH) on Temporal Change Detection of Land Use and Land Cover along the Linear Corridor of Siliguri-Jalpaiguri: A Geo-spatial analysis

<sup>1</sup>Arghadeep Bose & <sup>2</sup>Dr. Indrajit Roy Chowdhury

<sup>1</sup> Research Scholar, <sup>2</sup> Assistant Professor

Geography & Applied Geography

University of North Bengal, Darjeeling, West Bengal, India.

**Abstract:** Exponential growth of fastest urbanization and effective phenomenon of urban expansion is very common and reciprocal content of discussion in developing countries especially in India. In this regard Siliguri city is not an exception as it has been expanded since its inception because of its role as a transit town which caters dealers and businessman in wholesale and retail business with adjacent bordering areas. The development of Asian Highway Network is a co-operative Project among the countries in Asia, Europe and the United Nations Economic and social Commission for Asia and Pacific (ESCAP) to improve the connectivity and Accessibility of the highway system in Asia. As a part of AH project is associated with setting up two Asian Highways connecting three neighbouring countries through the districts of North Bengal followed by AH-2 connecting Panitanki near Siliguri on India- Nepal border and Fulbari in the same district with India- Bangladesh border. Therefore in this research paper temporal change detection analysis has been taken into consideration based on collected satellite image from earth explorer followed by land use and land cover (LU/LC) change between pre and post developmental project. However in this paper, an attempt has been made to point out the impact of this project along the linear corridor of Siliguri-Jalpaiguri as land use and land cover change and related regional development followed by SWOT analysis and change detection model of interpretation.

**Key word:** Change detection, Land use, Land cover, NDVI, NDBI, BUI, MNDWI.

## I. Introduction:

Land cover is the observed (bio) physical cover on the earth's surface (Di Gregorio, A., 2005) <sup>[1]</sup>, while land-use refers to the manner in which these biophysical assets are used by people (Cihlar, J., and Jensen, L.J.M., 2001) <sup>[2]</sup>. The availability of timely, reliable land-use information is becoming more important than ever in decision supporting process at various levels, both within a country and between countries (Di Gregorio, A., and Jansen, L.J.M., 2003) <sup>[3]</sup>. Generally the land use of urban area is associated with mostly residential and commercial areas. In urban areas the factors which led to the change of land use and land cover are increasing trend of population, expansion of built-up area, expansion of municipal boundary, governmental projects etc. In the present context with the Expansion of Bypass Road for Asian Highway Development Project and the National highway project the land encroachment pattern have changed through the Siliguri-Jalpaiguri linear corridor.

Here some specific literatures have been taken into consideration for the study of the impact of Expansion of Bypass Road and the land use land cover change through Siliguri-Jalpaiguri linear corridor. Wu et al., 2013 <sup>[4]</sup> postulated that "Increasing land use demand will place heavy pressure on the natural and semi natural ecosystems and necessary to support the human dominated ecosystem" in Hangzhou metropolitan area, china. Perz et al., 2008 <sup>[5]</sup> "Road building as a key determinant of Land use". Dolui, Das and Satpathy., 2014 <sup>[6]</sup> mentioned in their paper that "continuous growth of urban area is responsible for changing land use land cover pattern of any urban centre". Morara, MacOpiyo and Kogi-Makau., 2014 <sup>[7]</sup> stated that "Land use and cover changes resulted from activities due to human population growth and agricultural expansion in turn resulted in increase in riverine vegetation and woodlots". Fenta, Yasuda, Haregeweyn, Belay, Hadush, Gebremedhin, MeKonnen., 2017 <sup>[8]</sup> focused in their paper that "How built-up area is increased annually as a result of urban expansion in Mekelle city of northern Ethiopia". Basu, T. and Saha, S. K. 2017 <sup>[9]</sup> explained that "The rapid increasing population is one of the most significant factors of land use and land

cover change". Lambin, et al, 2003<sup>[10]</sup> stated that "Land use change is driven by synergetic factor combinations of resource scarcity leading to an increasing in the pressure of production of resources, changing opportunities created by markets, outside policy intervention, loss of adaptive capacity and changes in social organization and attitudes". Satiprasad, S. 2013<sup>[11]</sup> emphasised on understanding of LULC change detection analysis using LANDSAT (MSS in 1975, TM in 1989 and ETM+ in 2000) and LISS-III (2009) high resolution imagery for the 34 years of time span in Howrah city. Gupta, S. and Roy, M. 2012<sup>[12]</sup> explains the Land use land cover classification of Burdwan municipality with the help of LISS-IV imagery. Reymondin, et al, 2013<sup>[13]</sup> postulated that "The development of road projects in high value ecosystems and nearby protected natural areas increases pressure on natural habitats, threatens biodiversity conservation, and encourages the conversion of forest land into agricultural land". Daigle, P. 2010<sup>[14]</sup> stated that "Road effects on terrestrial and aquatic wildlife, plant communities and physical elements found across landscapes in British Columbia"

Land use and land cover of urban areas can be well explained with the help of certain index based methodologies. Some of the literatures associated with these indices are also taken into consideration. Xu, H. 2006<sup>[15]</sup> said that "The modified NDWI (MNDWI) can enhance open water features while efficiently suppressing and even removing built-up land noise as well as vegetation and soil noise". Szabo, et al. 2016<sup>[16]</sup> stated that "Landsat images with their 30 m resolution are suitable among others for land cover mapping and change monitoring and the water related indices (NDWI, MNDWI) were more effective (especially the MNDWI) to enhance water features". According to Bhatti, S.S., and Tripathy, N. K. 2014<sup>[17]</sup>, "The normalized difference built-up index (NDWI) has been useful for mapping urban built-up areas using Landsat Thematic Mapper (TM) data. The applicability of this index to the newer Landsat-8 Operational Land Imager (OLI) data was examined during this study, and a new method for built-up area extraction has been proposed". Kaimaris, D and Patias, P. 2016<sup>[18]</sup> stated that "The development of BUI (built-up Index) is based on the combination of the bands of Landsat ETM+: RED (band 3), SWIR (band 5) and SWIR2 (band 7)" Ahmed, et al. 2013<sup>[19]</sup> in his paper presented the application of the use of multi-temporal Landsat ETM+ images and multi-spectral MODIS (Terra) EVI/NDVI time-series vegetation phenology metrics for the district Sargodha.

The present study is associated with the impact of expansion of bypass road on spatio-temporal change detection analysis based approach. Here the pre-reviewed methodologies has been taken into consideration while computing the different indices and LULC features

## II. Objectives:

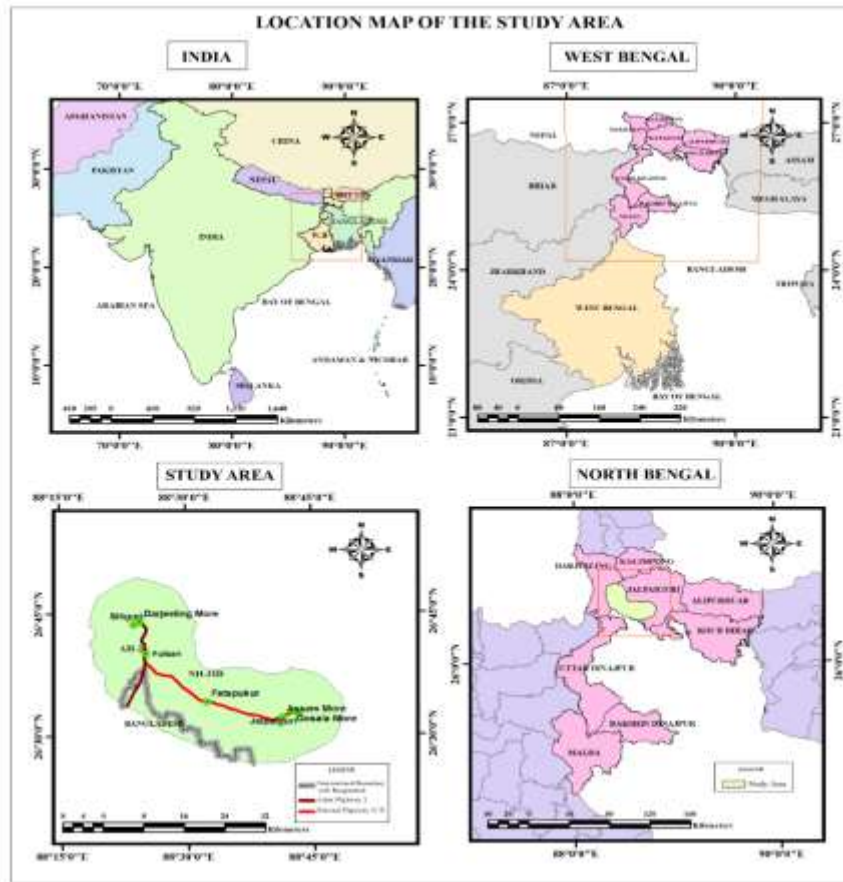
1. To analyse the overall connectivity and accessibility of the study area to assess the regional development.
2. To analyse the different dimensions related with LULC changes of the study area associated with the expansion of highways.
3. To identify different indices of LULC changes in the study area during 2011-2018.

## III. Historical background of Asian Highway:

The Asian Highway (AH) network is a co-operative project among countries in Asia and Europe and the United Nations Economic and Social Commission for Asia & Pacific (ESCAP) to improve the highway systems in Asia. The project aims to make maximum use of existing highways to avoid the construction of newer ones. In this regard AH-2 project is important. Its 13777 km long highway from Dempsar, Indonesia to Khosravi, Iran. A part of this AH-2 is connecting Panitanki (near India-Nepal Border) to Fulbari (near India- Bangladesh Border) in Darjeeling district of W.B. It is basically connecting three bordering countries through 38 km stretch with 11 km 4 lane and the rest with 2 lane. This landmark project will boost the connectivity with the neighbouring countries and friendship among SAARC countries.

**IV. Study area:**

For showing change associated with expansion of highways the study area is taken along the Siliguri-Jalpaiguri linear corridor. For this 10km/10km buffer area has been chosen as the study area along the Siliguri- Jalpaiguri linear corridor. With the expansion of highways for Asian highway and national highway development project the land encroachment pattern of the concerned area have changed.



**Fig-1: Location Map of the study area**

*Source: NATMO, Google earth and Computed by the Authors*

**V. Database & Methodology:**

The study was mainly associated with secondary databases, geo-informatics and statistical analysis. Also there has some primary data generated through survey for measuring the degree of congestion, associated with connectivity and accessibility of the study area.

Sl no.	Acquisition Date	Satellite/Sensors	Path/Row	No of Bands
1	12-09-2011	LANDSAT 5 TM	139/41	7
2	12-09-2011	LANDSAT 5 TM	139/42	7
3	23-11-2014	LANDSAT 8 OLI-TIRS	139/41	11
4	23-11-2014	LANDSAT 8 OLI-TIRS	139/42	11
5	11-10-2016	LANDSAT 8 OLI-TIRS	139/41	11
6	11-10-2016	LANDSAT 8 OLI-TIRS	139/42	11
7	17-10-2018	LANDSAT 8 OLI-TIRS	139/41	11
8	17-10-2018	LANDSAT 8 OLI-TIRS	139/42	11

*Source- United States Geological Survey, 2018*

**i. Image Processing:**

For the purpose of change detection using LULC maps, the LULC maps have been prepared in the Arc GIS (version: 10.2.2) software. The LANDSAT multispectral images were used to prepare the LULC classification maps. To get composite images layer stacking was performed then image enhancement techniques were applied in Erdas imagine 2014.

**ii. ROI creation and selection of macro classes:**

After completing the pre-processing of satellite image Regions of Interest were created based on the reflectance variability of the LULC classes. The selected macro classes of LULC are identified: Forest, Tea garden, Water body, Settlement, Agricultural Land and Sand depositions.

**iii. Algorithm used in classification:**

The remotely sensed LULC classification is based on 'Maximum Likelihood Classification' algorithm.

**iv. LULC maps and classification reports:**

After the completion of LULC classification, maps are prepared and from post-processing classification report further analysis have been done.

**v. Index Values:**

Different indices are calculated for the further analysis and better change detection of LULC classes such as-

Normalized Difference Vegetation Index (NDVI) (By Rouse et al., 1973) <sup>[20]</sup> is most commonly used significant indicator to monitoring vegetation condition, especially vegetation health condition. The NDVI images are calculated for 2011, 2014, 2016 and 2018 from visible Red (0.63-0.69  $\mu\text{m}$ ) and near-infrared (0.78-0.90  $\mu\text{m}$ ) by using the following mathematical formula:

$$\text{NDVI} = (\text{NIR} - \text{Red}) / (\text{NIR} + \text{Red})$$

In case of LANDSAT-5 it was the band 3 (red) & band 4 (NIR), and for LANDSAT-8 it was the band 4 (red) & band 5 (NIR)

Normalized Difference Build-up Index (NDBI) (By Zha, Gao and Ni., 2003) <sup>[21]</sup> is used to extract built-up features. It is performed through the following formula to represent BUI.

$$\text{NDBI} = (\text{MIR} - \text{NIR}) / (\text{MIR} + \text{NIR})$$

In case of LANDSAT-5 it was the band 5 (SWIR) & band 4 (NIR), and for LANDSAT-8 it was the and 7 (SWIR) & band 5 (NIR)

Build-up Index (By Zha, Gao and Ni, 2003) is calculated for detect the built-up and non-built-up areas. It is performed by the following formula,

$$\text{BU} = \text{NDBI} - \text{NDVI}$$

Modified Normalized Difference Water Index (MNDWI) (By Xu., 2005) <sup>[22]</sup> is an index to extract water bodies from satellite imagery. It is performed by the following formula,

$$\text{MNDWI} = (\text{Green} - \text{SWIR}) / (\text{Green} + \text{SWIR})$$

In case of LANDSAT-5 it was the band 2 (Green) & band 5 (SWIR), and for LANDSAT-8 it was the band 3 (Green) & band 6 (SWIR).

**vi. Statistical techniques:** For analysing the LULC report different statistical techniques are used like – Arithmetic mean, Correlation analysis (pearson), Linear regression (Galton), t-test, Rank score, Z score, ANOVA etc.

**VI. Results and Discussion:** The land use and land cover changes are explained by the following figures-

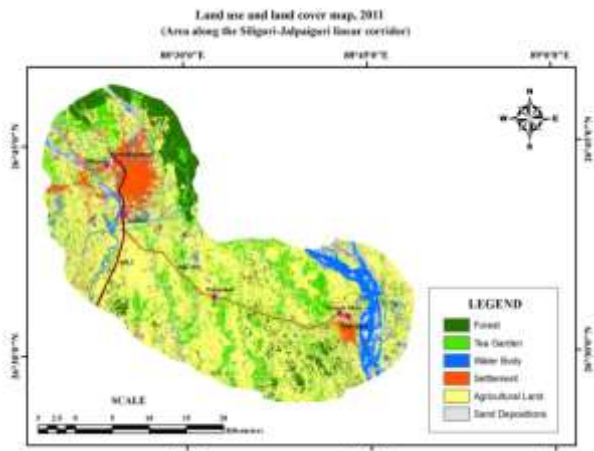


Fig-2: LULC map of 2011

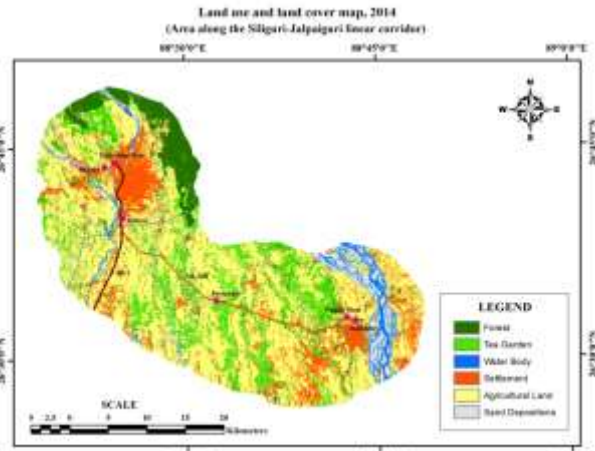


Fig-3: LULC map of 2014

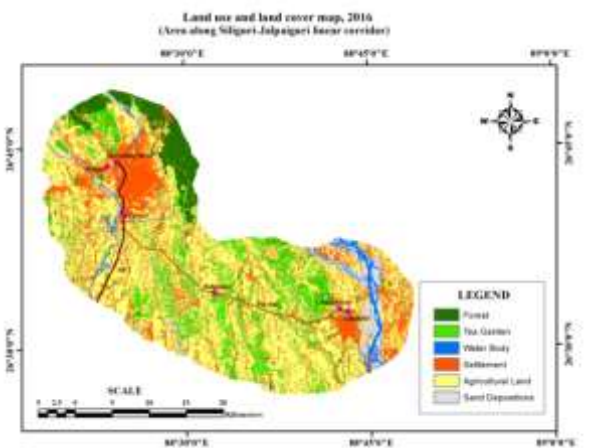


Fig-4: LULC map of 2016

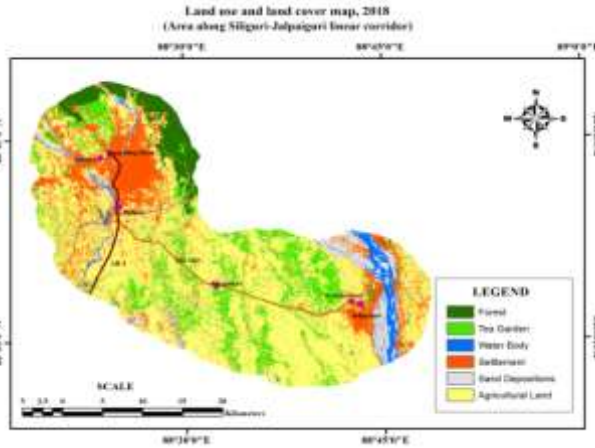


Fig-5: LULC map of 2018

Figure 2-5 shows the land use and land cover features along the Siliguri-Jalpaiguri linear corridor. Here six land use and land cover classes are identified i.e. forest, tea garden, water body, settlement, agricultural land and sand depositions. Total area of the region is 1112 sq. km. The land use and land cover is analysed for 2011,2014,2016,2018. From pre developmental phase of Asian and national highway expansion project and

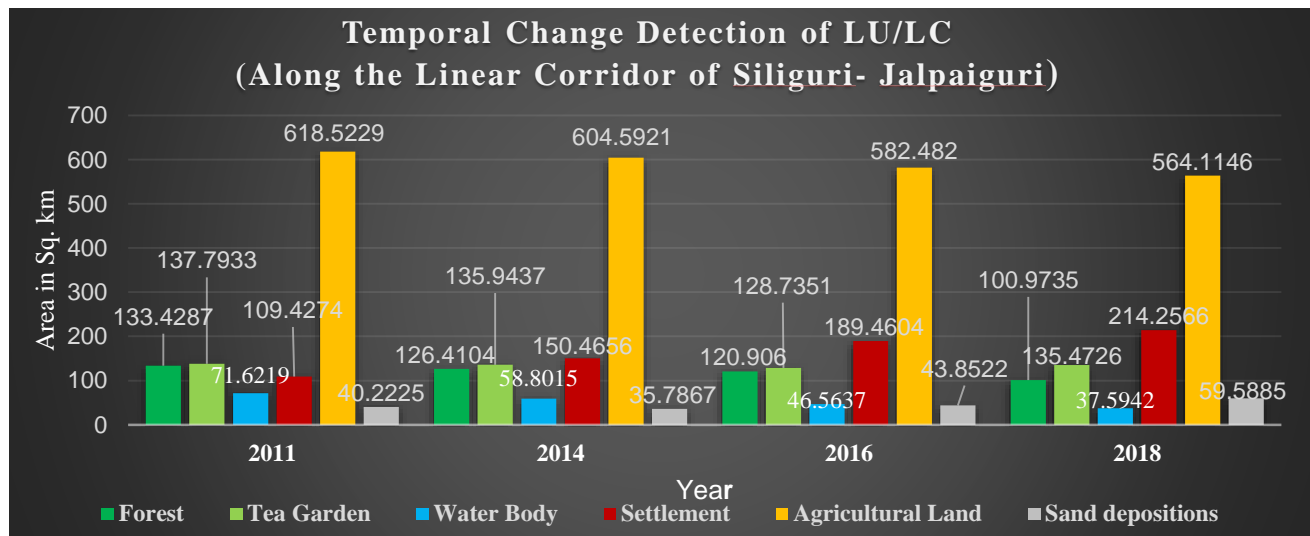


Fig-6: Area under land use and land cover classes from 2011-2018

present phase which is about to complete has been analysed here. In 2011 there was 133.43 sq. km forest area (12%), 137.79 sq. km tea garden (12.40%), 71.62 sq. km (6.38%) water body, 109.43 sq. km settlement (9.84%), 618.5229 sq. km (55.62%) agricultural land, And 40.22 sq. km (3.62%) sand depositions respectively.

Besides the total area (sq. km) under forest, tea garden, water body, settlement, agricultural land and sand depositions in 2014 is 126.41 (11.37%), 135.94 (12.14%), 58.80(5.29%), 150.47(13.53%), 604.5921 (54.37%), 35.7867 (3.22%) and in 2016 is 120.91 (10.87%),128.74(11.58%), 46.56 (4.19%), 189.46 (17.04%), 582.48 (52.38%), 43.85 (3.94%) and in 2018 is 100.97 (9.08%),135.47(12.18%), 37.59(3.38%), 214.26 (19.27%), 564.11 (50.73%), 59.59 (5.36%) sq. km.

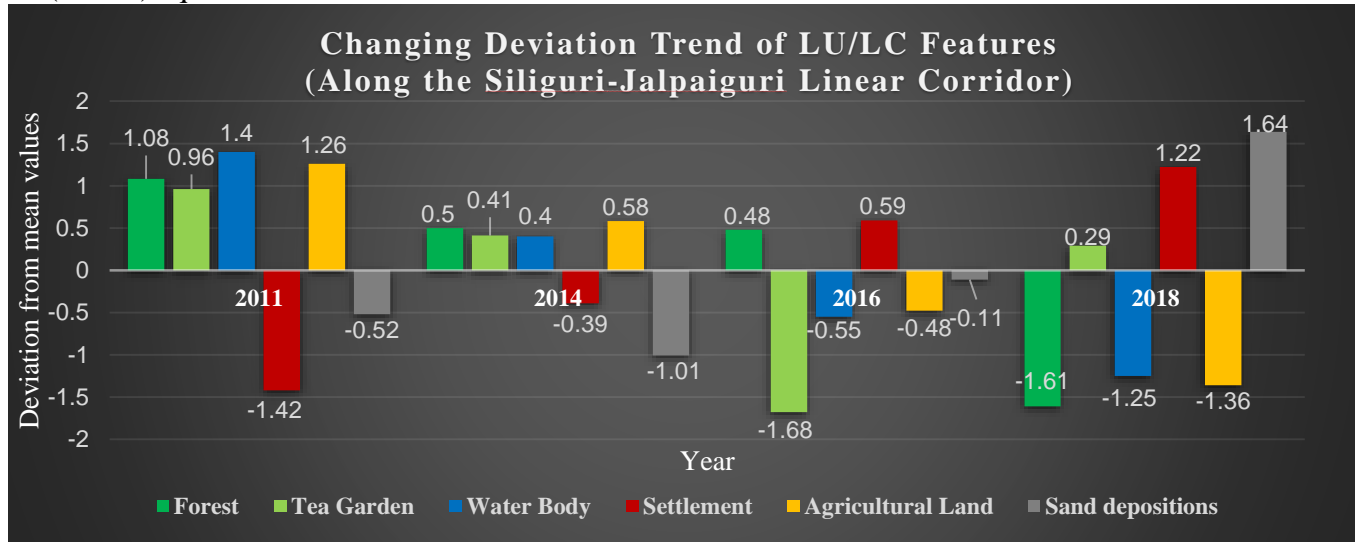


Fig-7: LULC changes from 2011-2018

After analysing the changing trend of LULC features it has been found that the built-up area i.e. settlement is continuously increased and the non- built-up areas i.e. forest, agricultural land and water bodies has been decreased

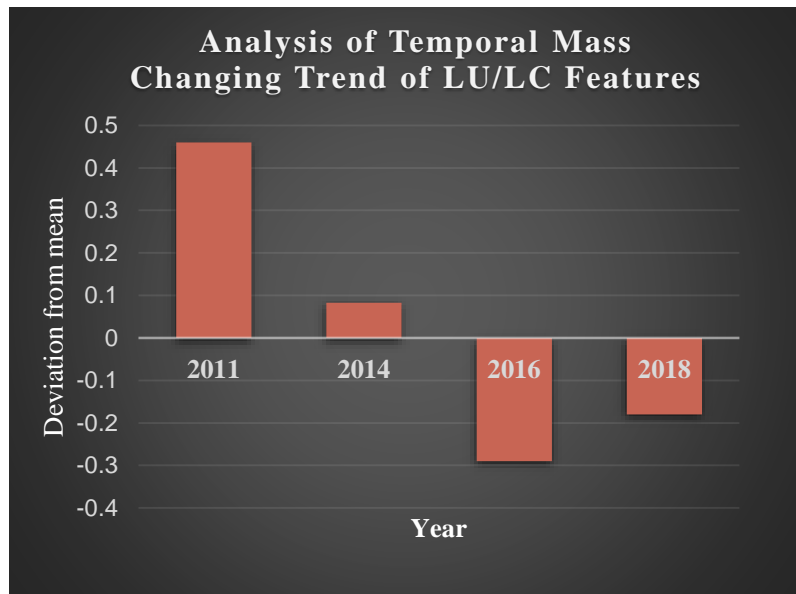


Fig-8: Analysis of temporal mass of LULC features

subsequently. The built-up areas has been changed positively because of the rapid urbanization associated with the increasing trend of connectivity and accessibility conversely the non- built up areas has been changed negatively as the built up areas replacing the natural surroundings. While analysing the temporal mass of LULC it has been found that from 2011 to 2014 there has been maximum change and afterwards from 2014 to 2016 there has moderate change, and finally 2016 to 2018 there has been minimum change seen in the area. This is because with the sands of time different planning authorities are working continuously like North Bengal Development Department (NBDD) and Siliguri-Jalpaiguri Development Authority (SJDA). So, the percentage of change is quite less in 2018 compared to 2011.

**Assessing Connectivity and accessibility:**

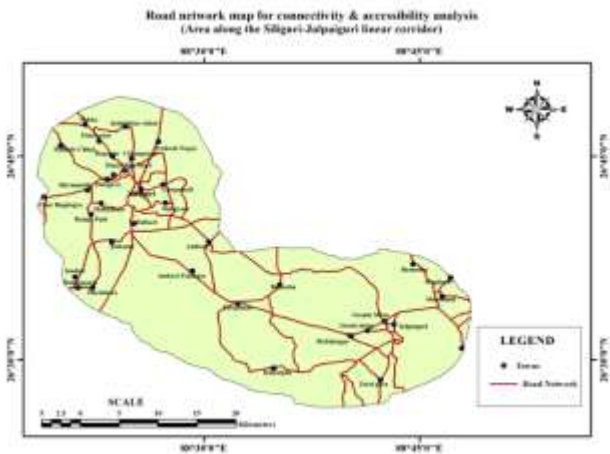


Fig-9: Road network map of the study area

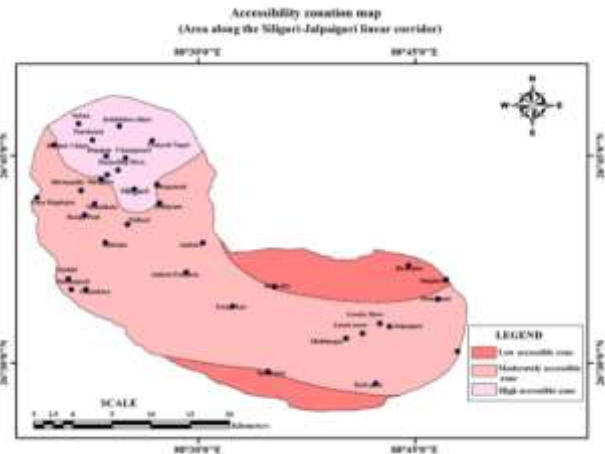


Fig-10 Accessibility Zonation map

<b>Connectivity Measures:</b>		
Here, E= No of Edges or Links, V= No of Vertices, G= No of Sub-Graphs, M/L= Total Route Length, D= Distance along the Diameter		
<b>Alpha Index or Redundancy Index (α) = E-V+G/2V-5</b>		
= 114-96+1/2*96-5		
<b>=0.1016</b>		
<b>Beta Index (β) = E/V</b>	<b>Gamma Index (γ) = E/3(V-2)</b>	<b>Eta Index (η) = M/E</b>
= 114/96	= 114/3(96-2)	= 894.9 km/114
<b>= 1.19</b>	<b>=0.4043</b>	<b>=7.85</b>
<b>Theta Index (θ) = M/V</b>	<b>Pie Index (π) = L/D</b>	<b>Cyclomatic Number (N) = E-V+G</b>
= 894.9 km/96	= 894.9 km/9001.68 km	= 114-96+1
<b>= 9.32</b>	<b>= 0.0994</b>	<b>=19</b>

After assessing the connectivity and accessibility of the study area through various connectivity measures it has been found that the area is moderately connected and accessible. There are high, moderate and low accessible zones are identified in the study area. Siliguri and surrounding areas are comprising high accessible zone and the outer portion away from the Siliguri Jalpaiguri linear corridor represents low accessibility and rest of the areas are moderately accessible and however the expansions of settlement areas are the result of increasing connectivity and accessibility. Therefore after the construction of Asian highway the connectivity and accessibility of the study area is tend to be developed as well.

**Measurement of the degree of Congestion:**

**Delay Rate (DR) = (Travel Time during peak period – Travel Time during off peak period) (Lomax .et. Al., 1997)**

By measuring the two important intersection points i.e. Darjeeling more and Gosala more in the region it can be said that the delay rate in Darjeeling more is 20 minutes that is higher than Gosala more i.e. 12 minutes and this is because of high amount of traffic flow through Darjeeling more.

Table no.1

Delay rate of Darjeeling More			
Roads Approaching	Peak period travel time	Off peak period travel time	DR
Towards Nougaghat	35 minute	15 minute	20 minute
Delay rate of Gosala More			
Roads Approaching	Peak period travel time	Off peak period travel time	DR
Towards Fatapukur	45 minute	33 minute	12 minute

**Travel Time Index (TTI)** = Peak period travel time/ off peak period travel time (Shrank and Lomax., 2005)

Table no.2 Travel Time Index of Darjeeling More			
Roads Approaching	Peak period travel time	Off peak period travel time	TTI
Towards Noukaghat	35 minute	15 minute	2.33
Travel Time Index of Gosala More			
Roads Approaching	Peak period travel time	Off peak period travel time	TTI
Towards Fatapukur	45 minute	33 minute	1.36

The average Travel Time Index is also high in Darjeeling more than Gosala more. Here the TTI of Darjeeling more to Noukaghat is 2.33 which is much higher than Gosala more to Fatapukur i.e. 1.36

**Lane-Length Duration Index (LLDI)** = Congested Lane Length × Duration of Congestion (Cottrell., 1991)

Table no.3 Lane Length Duration Index Of Darjeeling More			
Roads Approaching	Congested Lane length	Duration of Congestion	LLDI
Towards Noukaghat	287 metre	20 minute	5740
Lane Length Duration Index Of Gosala More			
Roads Approaching	Congested Lane length	Duration of Congestion	LLDI
Towards Fatapukur	112 metre	13 minute	1456

The Lane Length Duration Index of Darjeeling more is 5740 which is higher than Gosala i.e. 1456 more because Darjeeling more experience much higher traffic for longer period of time than Gosala more.

**Traffic Volume (TV)** = Total no. of vehicles in a specific time period

**Modal mix (MM)** = No of variety of modes for travelling

Table no.4 TV of Darjeeling more		
Roads Approaching	Traffic Volume	Modal Mix
Towards Siliguri	643	10
TV of Gosala More		
Roads Approaching	Traffic Volume	Modal Mix
Towards Siliguri	142	9

Traffic volume i.e. total number of vehicles and Modal mix i.e. variety of vehicles is also high in Darjeeling more than Gosala more. TV is 643 and MM is 10 in case of Darjeeling more and in Gosala more TV is 142 and MM is 9. So, we can say that Darjeeling more is more affected by traffic than

Gosala more.

Source: Primary Data & Calculated and Compiled by the Authors

**Relationship between Built-up Area and other Parameters of LU/LC**

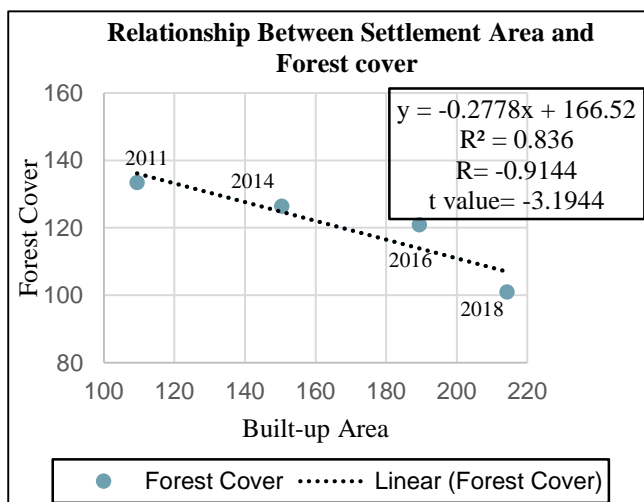


Fig-11 Relationship between Settlement area & Forest cover

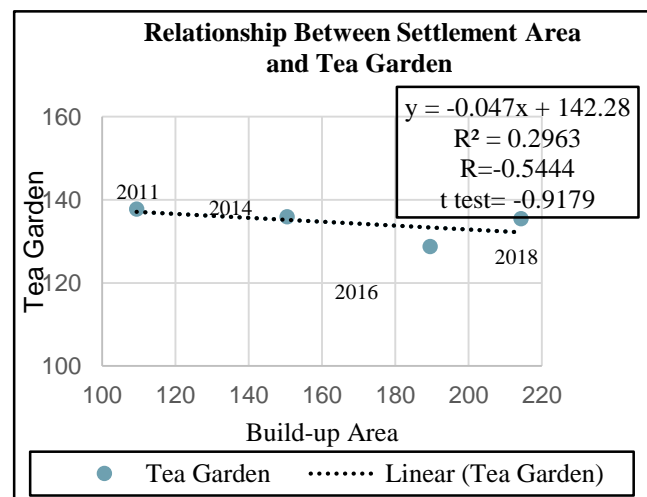


Fig-12 Relationship between Settlement area & Tea Garden

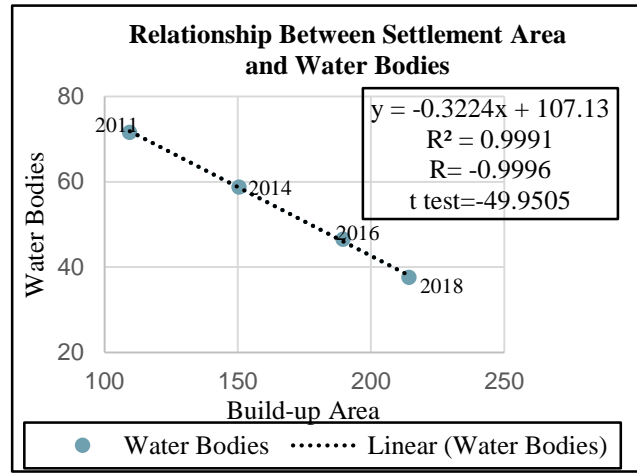
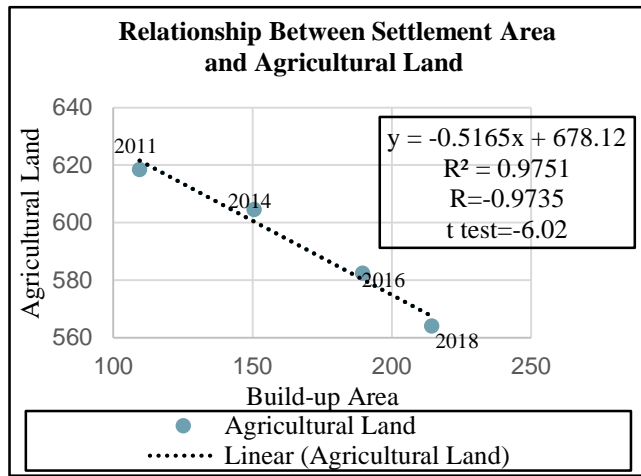


Fig-13 Relationship between Settlement area & Agricultural Land Fig-14 Relationship between Settlement area & Water Bodies

After analysing the scatter plot showing the relationship between built-up and non- built-up areas it has been found that the value of R is in negative form, showing the highly negative correlation between built-up and non-built-up areas. That shows with the increase of settlement, the non- built-up areas i.e. forest, tea garden, water body and agricultural land has been decreased continuously.

Year	Forest	Rank	Tea Garden	Rank	Water body	Rank	Settlement	Rank	Agricultural land	Rank	Sand depositions	Rank	Rank Score	Aggregate Rank Score
2011	133.429	4	137.7933	4	71.6219	4	109.4274	1	618.5229	4	40.2225	2	19	3.17
2014	126.41	3	135.9437	3	58.8015	3	150.4656	2	604.5921	3	35.7867	1	15	2.5
2016	120.906	2	128.7351	1	46.5637	2	189.4604	3	582.482	2	43.8522	3	13	2.17
2018	100.974	1	135.4726	2	37.5942	1	214.2566	4	564.1146	1	59.5885	4	13	2.17

Year	Rank score classes	Overall change
2011	>2.70	Maximum Change
2014	2.21-2.70	Moderate Change
2016, 2018	<2.20	Minimum Change

After analysing the Post classification data through rank-score method again it shows the mass change from 2011 to 2014 having maximum change, 2014-2016 having moderate change, and 2016-2018 having minimum change.

Sl no.	Features	2011 (t1)	(t1)2	2014 (t2)	(t2)2	2016 (t3)	(t3)2	2018 (t4)	(t4)2
1	Forest	166.5713	27746	174	30133.349	179.094	32074.6608	199.0165	39611.5477
2	Tea Garden	162.2067	26311	164	26914.47	171.2649	29331.6659	165.5274	27399.3201
3	Water Body	228.3781	52156.6	241	58176.716	253.4363	64229.9558	262.4058	68856.8038
4	Settlement	190.5726	36317.9	150	22360.567	110.5396	12219.0031	85.7434	7351.9306
5	Agricultural land	-318.5229	101457	-305	92776.347	-282.488	79796.0803	-264.1146	69756.5219
6	Sand depositions	259.7775	67484.3	264	69808.668	256.1478	65611.6954	240.5885	57882.8263
	Total	688.9833	311473	688	300170.09	687.9946	283263.0613	689.177	270858.9504

Source: Calculated and computed by the researcher

After doing analysis of variance (ANOVA) with considering all features of the concerned years from 2011 to 2018 at 0.05 significance level the calculated value is 0.00000628 which is less than the tabulated value 2.9. Because of this null hypothesis is accepted and it can be said that there is no abrupt change in the LULC in this eight years of time span. This is because from 2011 to 2018 there is very less time gap to show very big change in the concerned area.

### Determination of Index values:

Different indices are calculated and represented to analyse the values of changes of different LULC classes. These are Normalized Differential Vegetation Index (NDVI), Normalized Differential Built-up Index (NDBI), Built-up Index (BUI) and Modified Normalized Differential Water Index (MNDWI).

### Analysing the changes of Vegetation Density:



Fig- 15: NDVI of 2011

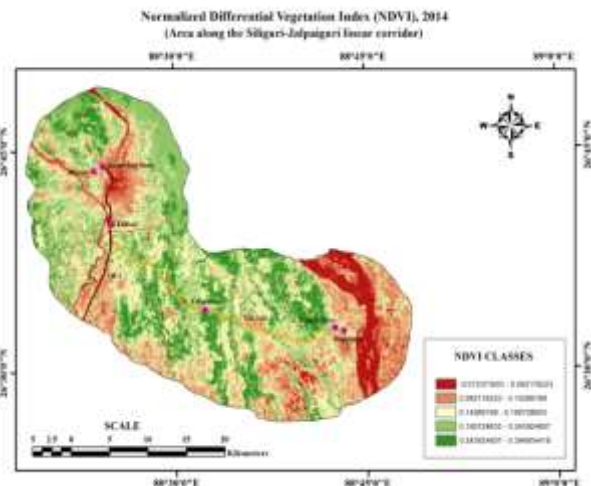


Fig-16: NDVI of 2014

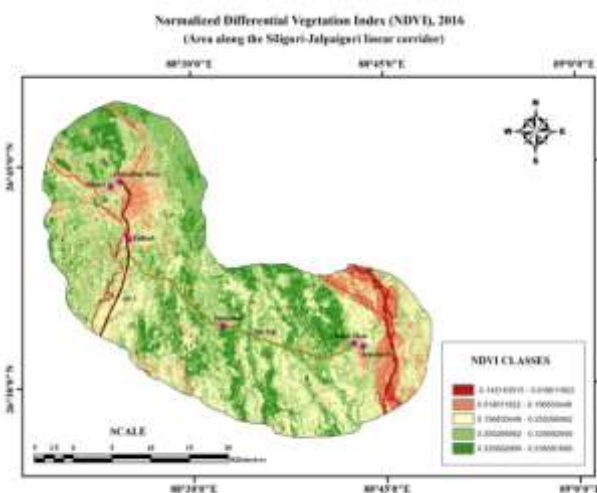


Fig-17: NDVI of 2016

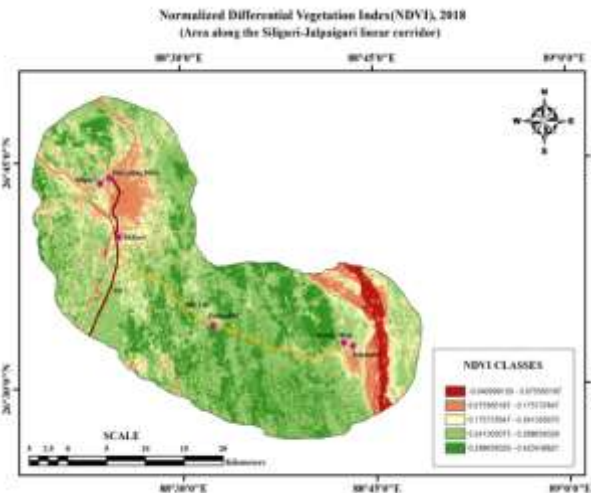


Fig-18: NDVI of 2018

The Normalized Differential Vegetation Index has been calculated for 2011, 2014, 2016 and 2018 to assess the vegetation density. NDVI is used to assess the vegetation health condition. The index values generally ranging from -1 to +1. Here the high positive values indicates the forest areas dominant with vegetation and the values closer to 0 or negative values indicate the dominance of water content. Here it has been observed that the vegetation patches were having declining trend of vegetation cover over the sands of time.

**Analysing the changes of Built up area:**

For analysing built-up areas Built-up Index (BUI) has been calculated from 2011 to 2018. BUI values also ranging from +1 to -1. Here the positive values are indicating the presence of built-up areas while the negative values are indicating the presence of non- built-up areas. The variation of built-up areas is shown by the analysis of BUI. Here the Patches of built-up areas clearly indicates the expansion of Siliguri and Jalpaiguri over time.

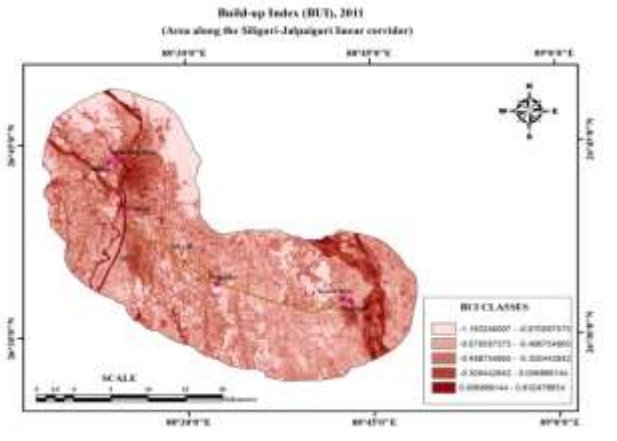


Fig-19: BUI of 2011

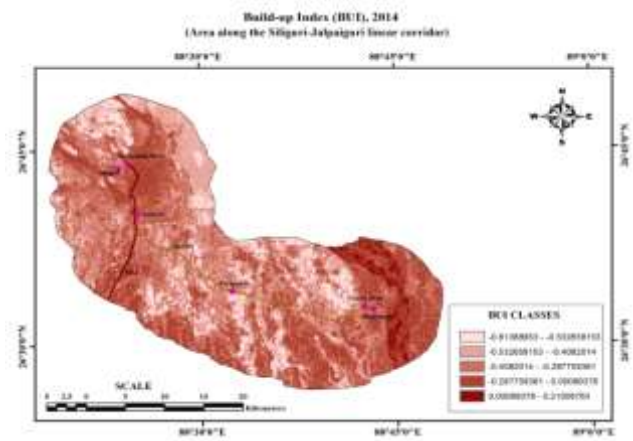


Fig-20: BUI of 2014

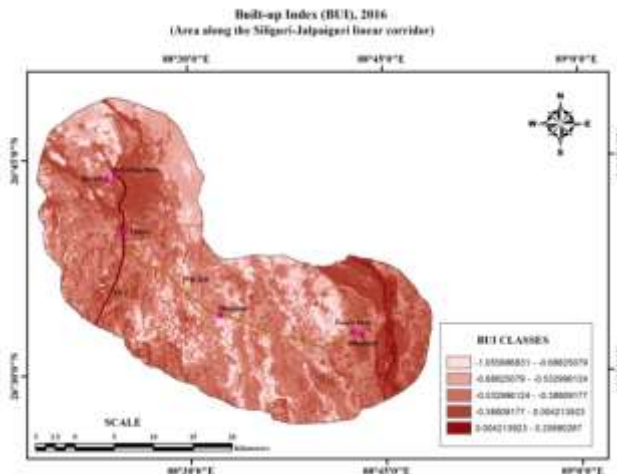


Fig-21: BUI of 2016

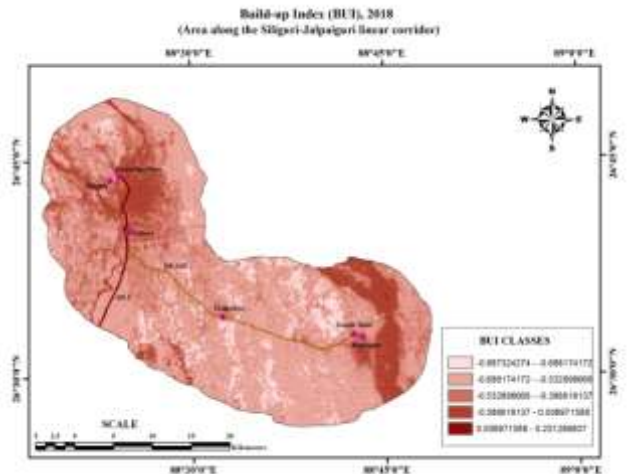


Fig-22: BUI of 2018

**Analysing the changes of Water bodies:**

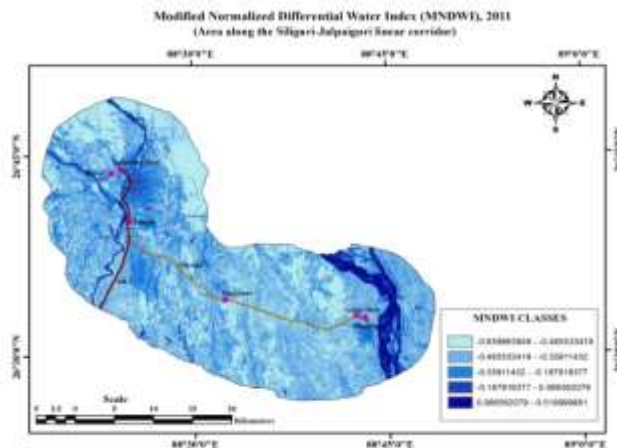


Fig-23: MNDWI of 2011

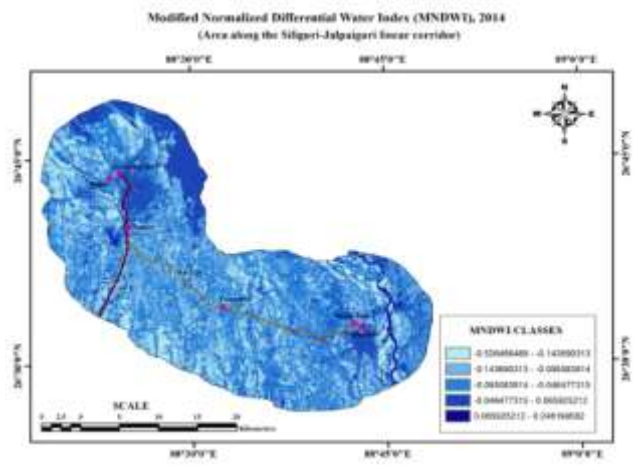


Fig-24: MNDWI of 2014

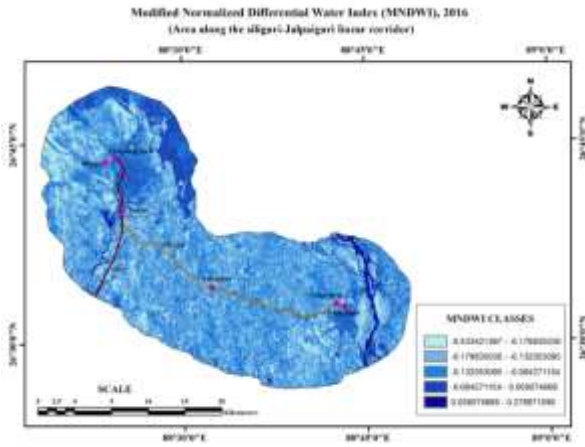


Fig-25: MNDWI of 2016

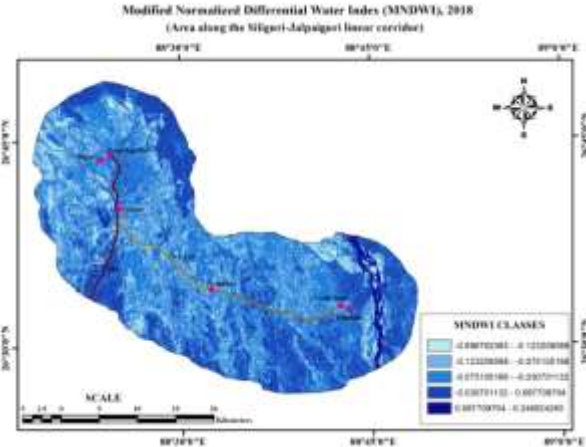


Fig-26: MNDWI of 2018

Modified Normalized Differential water Index is used for extraction of water bodies. Here the high positive value is associated with water bodies specially associated with rivers and negative or low values indicating marshy land or other features of LULC change. Here it has been clearly observed that over the period of time the sand depositions is increased in river Teesta, Mahananda and Balasan.

**Justifying LULC change through residuals:**

Table no.7

Year	Built-up (X)	Forest (Y)	$Y_c=a+bx$	Residual (Y- $Y_c$ )	Mean of the Residuals	Standard Error of Estimate
2011	109.4274	133.4287	-196.9438	-66.52	-92.96	134.9974
2014	150.4656	126.4104	-208.3483	-81.94		
2016	189.4604	120.906	-219.1849	-98.28		
2018	214.2566	100.9735	-226.0758	-125.1023		

Table no.8

Year	Built-up (X)	Tea Garden (Y)	$Y_c=a+bx$	Residual (Y- $Y_c$ )	Mean of the Residuals	Standard Error of Estimate
2011	109.4274	137.7933	-147.42	-9.63	15.59	23.03
2014	150.4656	135.9437	-149.35	-13.41		
2016	189.4604	128.7351	-151.18	-22.44		
2018	214.2566	135.4726	-152.35	-16.88		

Table no.9

Year	Built-up (X)	Agricultural Land (Y)	$Y_c=a+bx$	Residual (Y- $Y_c$ )	Mean of the Residuals	Standard Error of Estimate
2011	109.4274	618.5229	-735.5994	-117.0765	-172.5543	250.9298
2014	150.4656	604.5921	-756.9393	-152.4102		
2016	189.4604	582.482	-777.2166	-194.7346		
2018	214.2566	564.1146	-790.1106	-225.996		

Table no.10

Year	Built-up (X)	Water Bodies (Y)	$Y_c=a+bx$	Residual (Y- $Y_c$ )	Mean of the Residuals	Standard Error of Estimate
2011	109.4274	71.6219	-142.4116	-70.79	-106.97	155.5667
2014	150.4656	58.8015	-155.6424	-96.84		
2016	189.4604	46.5637	-168.2143	-121.65		
2018	214.2566	37.5942	-176.2086	-138.61		

Source: Primary data and computed by the researcher

With the help of residual computation through regression analysis the relationship between built-up area and non-built-up area has been analysed. Here the relationship of settlement as built-up area and forest, tea garden, agricultural land and water bodies as non-built-up area has been established. These residuals has been analysed for 2011,2014,2016,2018 respectively. When built-up vs. forest has been analysed the residuals are -66.52,-81.94,-98.28,-125.10 that means there is continuous decrease of the forest cover in the study area. Again for built-up vs. agricultural land residuals are -117.08,-152.41,-194.73,-225.99 and for water bodies these are -70.79,-96.84,-121.65,-138.61 that means agricultural land and water bodies has also decreased significantly. But for built-up vs. tea garden the residuals are -9.63,-13.41,-22.44,-16.88, here after rapid decreasing from 2011 - 2014 and 2014 – 2016, the amount of decreasing is reduced in 2016-2018. Because tea garden is a man-made feature and its expansion depends upon the local tea governing authorities.

## VII. SWOT analysis:

A summery SWOT analysis has been analysed for knowing the strength, weakness, opportunity and threats of the study area.

### Strengths

- The area is well connected and fairly good accessible with NH-31 as well as with the introduction of AH-2 with four lanes and flyovers the connectivity is increased.
- The area is well connected to the neighboring district headquarters and other towns. Also Siliguri plays a role as a main node for connectivity, being the gateway of NE India and also there is a good connectivity with neighboring countries.
- Siliguri and Jalpaiguri town being the administrative headquarters of Darjeeling and Jalpaiguri district plays a good role for the administrative coordination of the study area.
- There is availability of land along the corridor for further expansion.

### Weaknesses

- Huge amount of buildings/ shops were shattered during the AH-2 project along both side of the highway. So, the encroachment pattern of the land have changed.
- Haphazard traffic in the Darjeeling more area during peak hours.
- Movement of pedestrians & vehicles in the core Siliguri area during peak hours is difficult.

### Opportunities

- After the fulfillment of AH-2 project the relation with neighboring countries will increase.
- There is a huge opportunity of business with neighboring countries.
- Tourism industry of Darjeeling will be boosted by the well connectivity through the expansion of AH & SH. Also there is enormous scope of industrial development with in the region.

### Threats

- Problem of resettlement of the peoples who are basically affected by land encroachment.
- With the good connectivity there are increased amount of migrant force.
- There are uncontrolled building activities along the study area.
- With the expansion of highways the environment is partially hampered.

### VIII. Conclusion:

The land use and land cover situation of the area along the Siliguri-Jalpaiguri linear corridor is changing. With the expansion of bypass road through Siliguri-Jalpaiguri linear corridor the connectivity was increased. The analysis of Satellite imagery of the pre-developmental, developmental to present situation through LULC classification and various indices suggested that built-up area is rapidly increased and the non-built-up area is subsequently decreased like vegetation, water body, agricultural land etc. The increase of built-up area is obviously due to the well connectivity because the well connectivity is associated with settlement expansion through fringe areas. This is because of rapid urbanization associated with connectivity and accessibility. This situation is very much common in developing nations, where the rapid urbanization changes the natural landscape to cultural landscape.

### Reference:

1. Di Gregorio, A. (2005). *Land cover classification system: classification concepts and user manual: LCCS* (Vol. 2). Food & Agriculture Org..
2. Cihlar, J., & Jansen, L. J. (2001). From land cover to land use: a methodology for efficient land use mapping over large areas. *The Professional Geographer*, 53(2), 275-289.
3. Jansen, L. J., & Di Gregorio, A. (2003). Land-use data collection using the "land cover classification system": results from a case study in Kenya. *Land Use Policy*, 20(2), 131-148.
4. Wu, K. Y., Ye, X. Y., Qi, Z. F., & Zhang, H. (2013). Impacts of land use/land cover change and socioeconomic development on regional ecosystem services: The case of fast-growing Hangzhou metropolitan area, China. *Cities*, 31, 276-284.
5. Perz, S., Brilhante, S., Brown, F., Caldas, M., Ikeda, S., Mendoza, E., ... & Schmink, M. (2008). Road building, land use and climate change: prospects for environmental governance in the Amazon. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 363(1498), 1889-1895.
6. Dolui, G., Das, S., & Satpathy, S. (2014). An application of remote sensing and GIS to analyze urban expansion and land use land cover change of Midnapore Municipality, WB, India. *Int Res J Earth Sci*, 2(5), 8-20.
7. Morara, M. K., MacOpiyo, L., & Kogi-Makau, W. (2014). Land use, land cover change in urban pastoral interface. A case of Kajiado County, Kenya. *Journal of Geography and Regional planning*, 7(9), 192-202.
8. Fenta, A. A., Yasuda, H., Haregeweyn, N., Belay, A. S., Hadush, Z., Gebremedhin, M. A., & Mekonnen, G. (2017). The dynamics of urban expansion and land use/land cover changes using remote sensing and spatial metrics: the case of Mekelle City of northern Ethiopia. *International journal of remote sensing*, 38(14), 4107-4129.
9. Basu, T. and Saha, S. K. (2017). The Analysis of Land Use and Land Cover Changes Using Geo-informatics and Its Relation to Changing Population Scenario in Barasat Municipality in North Twenty Four Parganas, West Bengal, *International Journal of Humanities and Social Science Invention*, 6(8), 1-13
10. Lambin, E. F., Geist, H. J., & Lepers, E. (2003). Dynamics of land-use and land-cover change in tropical regions. *Annual review of environment and resources*, 28(1), 205-241.
11. Satiprasad, S. (2013). Monitoring urban Land use land cover change by multi-temporal remote sensing information in Howrah City, India. *PAN*, 520(900), 15.
12. Gupta, S., & Roy, M. (2012). Land Use/Land Cover classification of an urban area-A case study of Burdwan Municipality, India. *Int. J. Geomat. Geosci*, 2(4), 1014-1026.
13. Reymondin, L., Argote, K., Jarvis, A., Navarrete, C., Coca, A., Grossman, D., & Suding, P. H. (2013). *Road impact assessment using remote sensing methodology for monitoring land-use change in Latin America: Results of five case studies*. Inter-American Development Bank.
14. Daigle, P. (2010). A summary of the environmental impacts of roads, management responses, and research gaps: A literature review. *Journal of Ecosystems and Management*, 10(3).
15. Xu, H. (2006). Modification of normalised difference water index (NDWI) to enhance open water features in remotely sensed imagery. *International journal of remote sensing*, 27(14), 3025-3033.
16. Szabó, S., Gacsi, Z., & Balázs, B. (2016). Specific features of NDVI, NDWI and MNDWI as reflected in land cover categories. *Acta Geographica Debrecina Landscape & Environment*, 10(3-4), 194-202.
17. Bhatti, S. S., & Tripathi, N. K. (2014). Built-up area extraction using Landsat 8 OLI imagery. *GIScience & remote sensing*, 51(4), 445-467.

18. Kaimaris, D., & Patias, P. (2016). Identification and area measurement of the built-up area with the Built-up Index (BUI). *International journal of advanced remote sensing and GIS*, 5(6), 1844-1858.
19. Ahmad, F. (2012). Detection of change in vegetation cover using multi-spectral and multi-temporal information for District Sargodha, Pakistan. *Sociedade & Natureza*, 24(3), 557-571.
20. Rouse Jr, J., Haas, R. H., Schell, J. A., & Deering, D. W. (1974). Monitoring vegetation systems in the Great Plains with ERTS.
21. Zha, Y., Gao, J., & Ni, S. (2003). Use of normalized difference built-up index in automatically mapping urban areas from TM imagery. *International journal of remote sensing*, 24(3), 583-594.
22. Han-Qiu, X. U. (2005). A study on information extraction of water body with the modified normalized difference water index (MNDWI). *Journal of remote sensing*, 5, 589-595.
23. Lomax, T. J., & Levinson, H. S. (1997). Overview of congestion measurement principles. In *Traffic Congestion and Traffic Safety in the 21st Century: Challenges, Innovations, and Opportunities* Urban Transportation Division, ASCE; Highway Division, ASCE; Federal Highway Administration, USDOT; and National Highway Traffic Safety Administration, USDOT.