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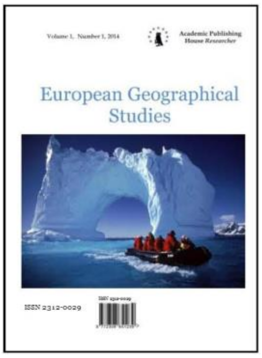

A Comprehensive Assessment of Land Use and Land Cover in Lateritic terrain through Remote Sensing and GIS in West Bengal

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Abstract

Climate change is an important consequence of the land degradation. There is an urgent need to manage the rapidly changing dynamicity of the earth surface in a sustainable way. Garbeta block of West Medinipore has been chosen for the study to identify the sources of landform vulnerability which is severely affected by rill and gully erosion. Land use and land cover analysis of three distinct years has been computed which clearly shows the increase of dry fallow land over the region from 1989 to 2018 making it more assailable to sheet and rill erosion during the monsoonal period and encourage poor ground water recharge. An association map between land use/land cover and elevation has been prepared using GIS software and Statistical Package for the Social Science (SPSS) to find out the dominancy and similarity of a particular physical and human activities over the region according to the relief. The environmental indices like Normalized Difference Vegetation Index (NDVI) and Normalized Difference Water Index (NDWI) has been prepared to analyse the ecological stability of the region. Therefore land use and land cover analysis is an important tool for the policy makers and stakeholders to implement conservation schemes in the light of sustainability.

Keywords: water stress, Multiple Correspondence, Kappa statistics, NDVI, NDWI.

1. Introduction

Land use and land cover assessment is one of the most important tool of quantifying and qualifying the earth surface equilibrium. The dynamicity of the frequent landform configuration can be easily monitored by applying this methodology. Environmental degradation together with alarming rate of population growth has been modifying our valuable land resources since its birth. Human induced land use and land cover change has brought far reach implications on the climate change by instigating the global carbon cycle and increase of atmospheric CO_2 to a greater limit. According to Xiao et al. (Xiao et al., 2006: 322) land use and land cover switch play major role in global climate change through its interaction with ecosystem and ecology. This change can be detected and investigated by the amalgamated methodology of remote sensing and Geographical Information System (GIS) (Wu et al., 2006: 322). In order to monitor the change in large areas accurate and effective mapping techniques can be used and that can be done using remotely sensed images like Landsat ETM+ and Landsat 8 OLI (Mas, 2004: 219). Ravines or the regions of irregular terrains are crisscrossed by numerous rills and gullies like that of the west Bengal Rarh plain which

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frequently modifies the land surface. The absence of the vegetation and high density storm events leads to the formation of scour rims and makes the region unfavourable for economic growth. Such mix of tropical and semi –arid kind of climatic region is also effected by water unavailability and the first and the foremost reason is the land degradation. The massive propagation of population, their activities and encroachment has made the situation more vulnerable one. This frequent and continuous landform modification can be traced using modern GIS techniques as well as by methods of machine learning like fuzzy logic and Artificial Neural Networks (ANN) (Mas, 2004: 219). According to Yang and Lo (Yang, Lo, 2001: 1775) the use of remote sensing will be successful in detecting the land use and land cover change after having a complete understanding of the landscape features prevailing over the region. According to Gomarasca et al. (Gomarasca et al., 1993: 211) highly detailed mapping of the land use and land cover can be obtained through spatial, radiometric and spectral resolution of Landsat images. Documentation of the pattern of change, when and why they occur, rate of change and social and physical forces that drives those pattern are needed (Mengista, Salami, 2007: 99). Map to map comparison is needed for identification of variability between two maps of different year and same season (Green et al., 1994:331). Land use and land cover change of sub watersheds of Madhya Pradesh through IRS LISS of 1989 and IRS LISS III of 20001 brought significant results and proved useful for planners and managers (Javed et al., 2009: 261). Different techniques of image classification can be used to monitor the change pattern. Supervised and unsupervised are the two most important classification technique can be done in GIS software. Supervised classification technique in ERDAS Imagine 9.2 provided good classification and accuracy results while mapping spatial-temporal dynamics of land surface of Almora, Uttarakhand (Rawat, Kumar, 2015: 77). According to Yang and Lo (Yang, Lo, 2001: 1775) digital image classification played an important role in revealing the loss of forest and urban sprawl development in Atlanta, Georgia metropolitan area. More appropriate method to validate the classification technique is to gather the ground truth information from field investigation and it helped in tracing the vegetation degradation and water logged region of the coast of Egypt (Shalaby, Tateishi, 2007: 28). The Relative Operating Characteristics (ROC) is a quantitative analysis of the land use and land cover validation model and helps in simulating the future probability (Jr, Schneider, 2001:239) .According to Shalaby et al., (Shalaby et al., 2004: 28) encroachment by the urban settlement on arable land may pose undesirable consequence on the land degradation and land desertification. Image enhancement and visual interpretation made an improvement of the supervised classification and helped to observe the effects of human activities like formation of free water bodies, sabkhas and open quarrying in West Nile delta of Egypt (Kawya et al., 2010: 483). Recently the remote sensing and GIS with incorporation of global positioning system proved useful is analysing and modelling urban growth and expansion in Shijiazhuang region of china (Xiao et al., 2006: 69). Thus it can be also an important tool of monitoring population dynamics in the developed and developing countries of the world. The uneven urban growth made a major role loss of cropland between 1989–2001 which has been monitored by using GIS technology and Markov model which helped the landscape managers to provide recommendation to stabilise it (Wu et al., 2006: 322).

The main objective of the paper is to apply remote sensing and GIS technology in quantifying the change analysis of a dynamic landform over a period of nearly 30 years which was severely affected by sheet, rill and gully erosion. The scope of the study include (i) detection of change of land use and land cover between the period of 1989-2000 and 2000- 2018 and preparation of post classification multi- date comparison change table (ii) to understand the pattern of association between elevation and land use and land cover of 2000 and 2018 (iii) assessment of the two different environmental indices i.e. Normalised Difference Vegetation Index (NDVI), Normalised Difference Water Index (NDWI).

2. Materials and methods

2.1 .Study area: The study area is located in the lateritic ravine of West Bengal in the district of West Medinipore along the bank of river Shilabati which is the main river of the region. Garbeta Block-1 is a community development block (Figure 1) in the Medinipore Saradar sub-division. The region is located within the latitudinal extent of 22°47’12” N to 22°56’27” N and 87°

13’17” E and 87°56’ 27” E longitude. The area is characterised by lateritic soil that falls under the Rarh category of West Bengal located at the margin of the chotonagpur plateau margin.

2.2.Topography: A part of Garbeta block -1 is often analoged with the Grand Canyon of USA and such similar feature can bee seen at the middle of block popularly called ‘ Gangoni’ near the bank of Shilabati river. Where the elevation (Figure 2) is slight higher with greater slope. The region is very much prone to erosion which falls under the cratonic margin of the Bengal basin (Shit et al., 2014: 161). The surface of the land is charecterised by irregular topography starting from the barren laterite upto hard and rocky terrain which are influenced by frequent rill and gully formation during time of high runoff that can be visualy observed in the stream ordering map of the study area. The region is criss crossd by numerous 1st order streams originating(Figure 3) from the gully heads and meets the 5th order streams i.e. Shilabati river which carries away greater amount silt and clay deposits along its bed choking the river’s normal flow.

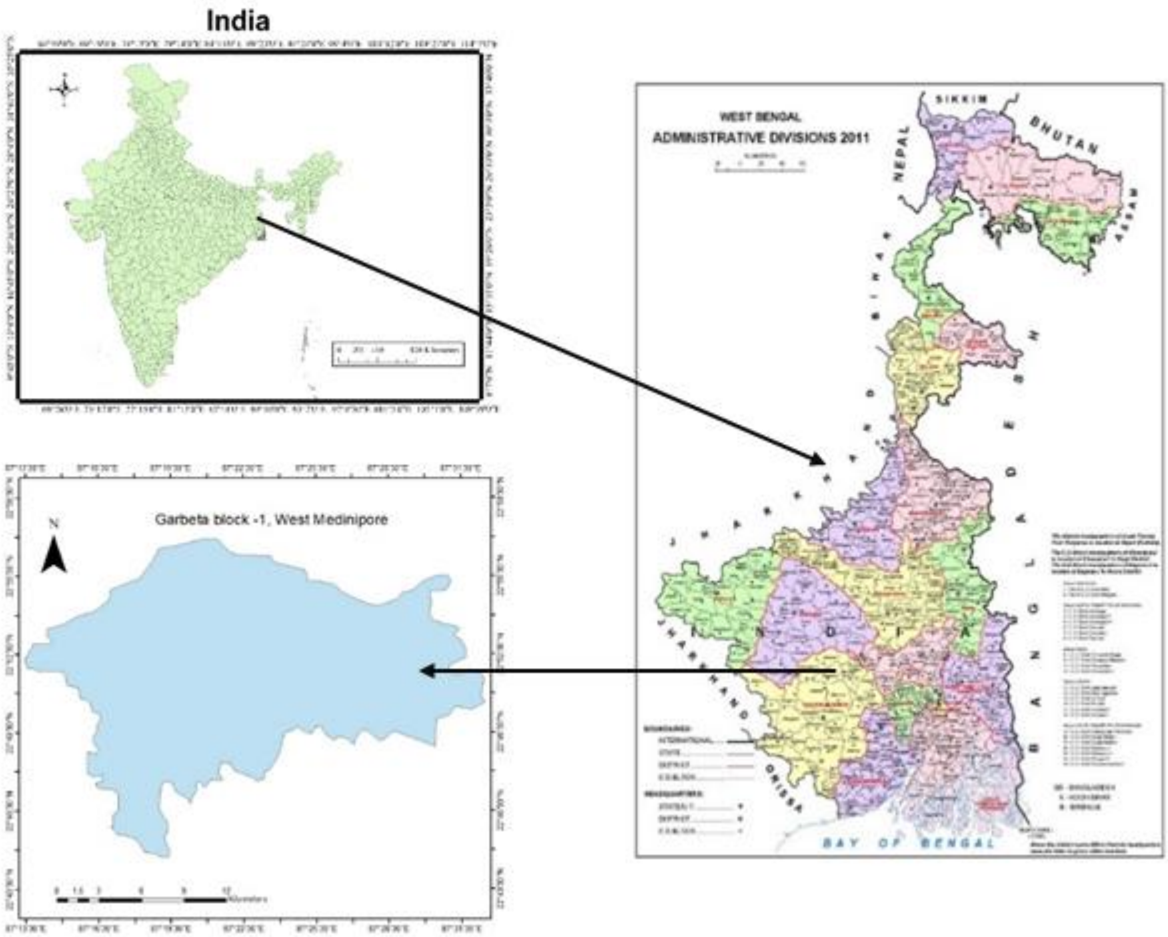

Fig. 1. Location map of the study area

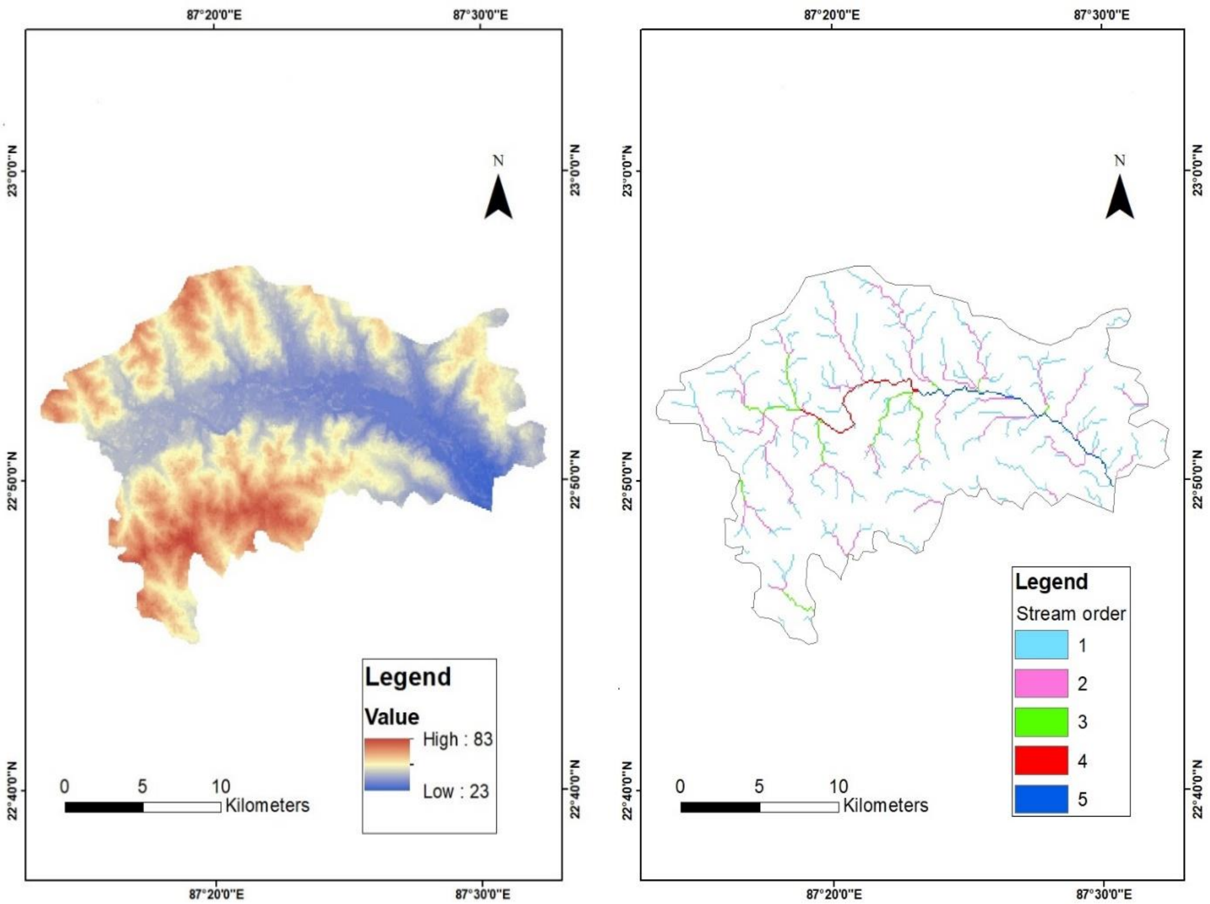

Fig. 2. Digital Elevation Mode

2.3.Data accquring and data processing: The methodology of the study include the downloading of Landsat data sets (path/row -139-44) (Table 1) from the United Nation Geological (USGS) website (http://earthexplorer.usgs.gov/) of the three consecutive years of same month. All the bands (Table 2) of the respective years has been processed in ERDAS imagine 9.2 software and stacked to prepare False Colour Composite (FCC) map.The study area has been cropped out by using the subset tool of the respective software.Image classification has been done using the same GIS software through supervised classification method.The study area has been classified into nine classess, the description of which is given in the Table 3.The accuracy assessment of the each land use and land cover has been calculated in the excel software by using error matrix generated from signature file of each maps in ERDAS Imagine 9.2. A change detection table has been prepared by combining land use land cover maps of 1989,2000 and 2018.The association between the elevation and land use and land cover has been mapped using SPSS software package. The Suttle Radar Topographic Mission digital (SRTM) elevation model of 90m resolution has been used to extract the elevation values of the region(Figure 2). The DEM and the land use/cover map of year 2000 and 2018 was combined in the ArcGIS software and exported to SPSS software to calculate multiple corespondance analysis.

2.4.Normalised Difference Vegetation Index (NDVI): It is an important tool to depict the vegetation cover, monitering drought ,predicting agricultural productivity, assessing hazardous fire zones and mapping desert enroachment. The NDVI values of less than 0 indicate water content, 0 to 0.1 bare soil and over 0.1 indicates vegetation. The increase in the positive value depicts the greater greenry and highest possible vegetation density. It is calculated using the followin formula:

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

Table 1. Information on data acquisition

Image	Date of acquisition	Path/row
Landsat 4 & 5	23.03.1989	139/44
Landsat ETM +	29.03.2000	139/44
Landsat 8 OLI	7.03.2018	139/44

2.5.Normalised difference Water index (NDWI): The Normalised Difference Water Index is used to asess the water content of water bodies in a particular region (McFeeters, 1996: 1425).The value basicaly ranges from -1 to 0 which depicts no water content or water stressed region and values near +1 indicates water content. It is calculated using the formula:

$$NDWI = \frac{Green - NIR}{Green + NIR} \text{............}(2)$$

Table 2. Specifications of Landsat band used in the study

Class	Description
Dense forest	Forest with more than 70 % canopy covrage with highest possible density of greenery.
Open forest	It inludes tree canpy with more than 10% coverage of greenery.
Agricultural land	It include the crop fields.
Agricultural wet fallow	land under wet condition,arable and processed for agricultural growth
Dry fallow	Open bare surfaces composed of loose soil materials in dried condition exposed to frequent rill and gully erosion
Settlement	It includes the residential,industrial,commercial zones,transpoation lines, road,small houses and urban growth
Water body	It includes the river,ponds,lakes,free water surface and reserviors.
Lateritic exposure	It includes the erroded top soil which lead the exposure of laterite soil at A horizon.
sandbar	Sand deposits along the river bed.

Table 3. Description of Land use and land cover classes

Landsat Image	Band	Wavelength	Spatial resolution
Landsat 5	Band-2-Green	0.52-0.60	30
	Band-3- Red	0.63-0.69	30
	Band-4- Near Infra Red	0.76-0.90	30
Landsat ETM+	Band-2-Green	0.525-0.605	30
	Band-3-Red	0.630-0.690	30
	Band-4-Near Infra Red	0.760-0.900	30
Landsat 8	Band-3-Green	0.53-0.59	30
	Band-4-Red	0.64-0.67	30
	Band-5-Near Infra Red	0.83-0.88	30

3. Results and Discussion

3.1. Accuracy assessment of the classified maps: Accuracy assessment is critical and important while asessing land use and land cover map generated from any remotely sensed data and calculation of Kappa statistics add extra significance to it.The accuracy assessment of the classified maps has been calcualted using error matrix, generated after the employing supervised classification in ERDAS Imagine (Table 4, 5, 6).The classification accuracies of the three consecutive maps proved out to be better than expected.The user accuracy of the three classified maps (1989, 2000 and 2018) ranged between 75% to 100% and the producer accuracy of them varied between 89 % to 100 %. The overall accuracy was high and was 97 % for 1989, 97 % for 2000 and 96 % for 2018.The kappa coeffiecent was 96 % for 1989, 96 % for 2000 and 95 % for 2018 respectively. This acccuracy assessment is validated with the gorund truth points to ensure its appropiate efficency by using toposheets no: 73N/5.

3.2. Land use and land cover analysis : Land use and land cover analysis has been done by taking three disctint years i.e 1989, 2000 and 2018 in order to find out the mode of land configuration in the study area (Figure 7). The land use map of 1989 shows (Figure 4) the greater extent of agricultural wet fallow which is about 176.85 Km^2 and the dense forest coverage of 55.62 km^2. In 2000 (Figure 5) these classes are showed a dcreasing trend, The dense forest cover decreased from 15.01 % in 1989 to 8.13 % in 2000 which clearly depicts the sign of forest degradation. From 1989 to 2000 the percentage of agricultural land increased along with the increase of water bodies which may be due to the increase in the population presssure over the region. According to census 2001 the total population of Garbeta block – 1 is about 200,393 and in 2011 it became 228,513. The percentage of dense forest cover increased in the year 2018 (Figure 6) which may be due to the joint forest managemnet schemes implemented over the region. Area under dry fallow increased from 2000 to 2018. The percentage of land under dry fallow increased from 9.31 % to 16.52 % which signifies gerater soil loss and infertily to triger in the study area. Conservation of dry fallow regions are at urgent need as the area is already being vulnerable with rill and gully erosion.

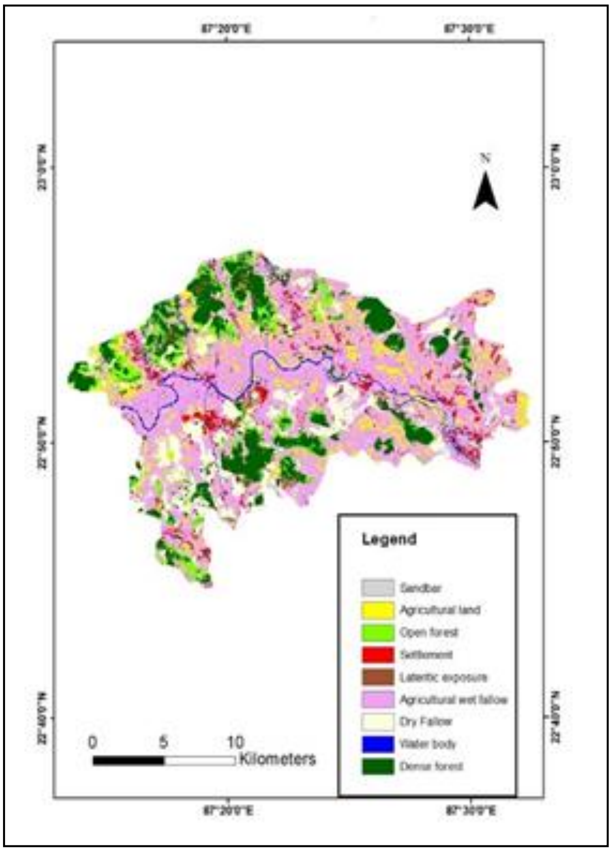

Fig. 4. Land use and land cover map of 1989

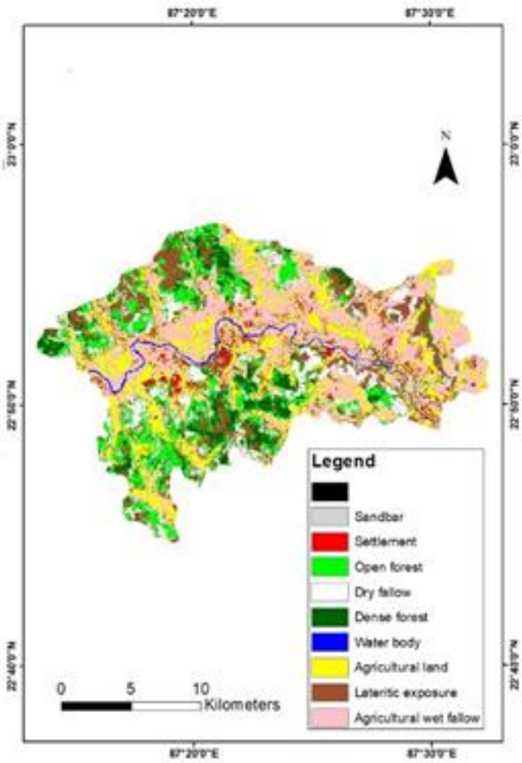

Fig. 5. Land use and land cover map of 2000

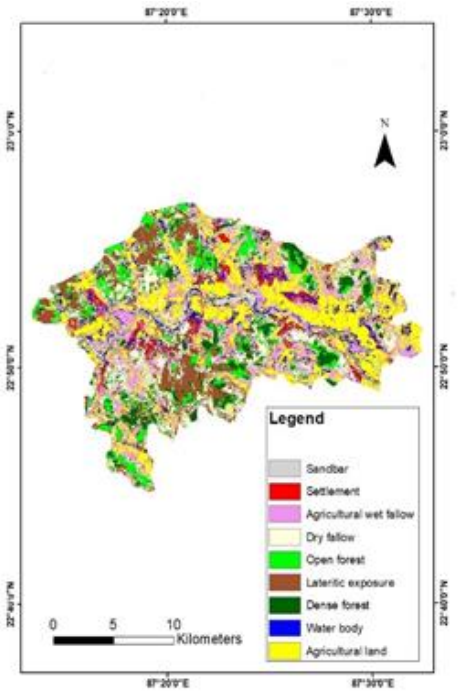

Fig. 6. Land use and land cover map of 2018

3.3. Change detection analysis: A change detection table has been prepared using ArcGIS software to find out the pattern of land conversion from one class to another. From the table below (Table 9) it can been seen that a large part of dense forest is mainly converted to dry fallow in 2018 from 1989. In case of the open forest most of the area under it has been deforested and changed into dry fallow. Greater part of the agricultural wet fallow has been converted to agricultural land to meet the need of the growing population. The other classes showed similar kind of conversion trends. From the change detection table (Table 9) it can be said that the region has modified far reach to cope up with the changing environmental and population scenario.

3.4. Multiple Correspondence analysis

Multiple correspondence analysis is a type of principle component analysis and an important technique used in this paper to show the mode of association between the landform class and elevation of the region. It has been prepared with help of ArcGIS and SPSS software for the year 2000 and 2018. The elevation map has been prepared from SRTM DEM. Both land use / land cover map and elevation map has been reclassified (Table 10) in ArcGIS using reclass tool and the association map has been prepared in SPSS software. In the map of 2000 (Figure 9A, B) it can be seen that in the class 5 i.e. at an 66-83m of elevation, dense forest and lateritic exposure can be found, between the elevation of 56-66 open forest exist, between 46-56m dry fallow can be seen and near the elevation of 37-46 m and 23-47 m agriculture land, agricultural wet fallow, settlement and water bodies can be found. The close proximity between two parameters indicate greater area coverage by a particular class in an elevation. For example greater percentage of the area under dense forest lies at an elevation of 66-83m.But in 2018 a change in the land use/land cover configuration with the elevation has been occurred (Figure 9 A, B). The dense forest is mainly seen at a close proximity near the elevation class of 4 i.e. between 56-66 m and it can be concluded that a part of dense forest at the elevation of 66-83 m of 2000 has been degraded or deforested. Thus at present the bare land is in the higher elevation with lateritic exposure which encourages greater chances of soil erosion. The land use and land cover map also depicts such kind of trend where the percentage of dense forest has been reduced when compared to the map of 1989 to present (2018). This method of analysis helps in understanding correlation between the physical, social and economic land form characteristics with an elevation of a region and helps managing the land in a planned way.

Table 4. Accuracy assessment of land use and land cover map of 1989

Class name	Agricultural wet fallow	Agricultural land	Water body	Sand bar	Open forest	Settle-ment	Dry fallow	Dense forest	Lateritic exposure	Row total	User accuracy (%)	Producer accuracy (%)
Agricultural wet fallow	163	3	0	0	0	5	2	0	6	179	91	97
Agricultural land	0	187	0	0	0	1	0	6	0	194	96	98
Water body	0	0	271	0	0	1	0	0	0	272	99	99
Sand bar	0	0	0	9	0	0	0	0	0	9	100	100
Open forest	0	0	0	0	92	0	0	1	0	93	99	100
Settlement	3	0	3	0	0	952	0	118	29	1105	86	95
Dry fallow	1	0	0	0	0	0	2103	0	0	2104	99	99
Dense forest	0	1	0	0	0	16	0	3927	5	3319	99	96
Lateritic exposure	0	0	0	0	0	27	0	6	259	792	96	96
Column total	167	191	274	9	92	1002	2105	3428	799			
Overall accuracy (%)	97											
Kappa Statistics (%)	96											

Table 5. Accuracy assessment of land use and land cover map of 2000

Class name	Agricultural wet fallow	Agricultural land	Water body	Sand bar	Open forest	Settle-ment	Dry fallow	Dense forest	Lateritic exposure	Row total	User accuracy (%)	Producer accuracy (%)
Agricultural wet fallow	163	3	0	0	0	5	2	0	6	179	91	97
Agricultural land	0	187	0	0	0	1	0	6	0	194	96	98
Water body	0	0	271	0	0	1	0	0	0	272	99	99
Sand bar	0	0	0	9	0	0	0	0	0	9	100	100
Open forest	0	0	0	0	92	0	0	1	0	93	99	100

Settlement	3	0	3	0	0	952	0	118	29	1105	86	95
Dry fallow	1	0	0	0	0	0	2103	0	0	2104	99	99
Dense forest	0	1	0	0	0	16	0	3927	5	3319	99	96
Lateritic exposure	0	0	0	0	0	27	0	6	259	792	96	96
Column total	167	191	274	9	92	1002	2105	3428	799			
Overall accuracy (%)	97											
Kappa Statistics (%)	96											

Table 6. Accuracy assessment of land use and land cover map of 2018

Class name	Laterite exposure	Dense forest	Open forest	Agricultural wet fallow	Agricultural land	Water body	Dry fallow	Settlement	Sandbar	Row total	User accuracy (%)	Producer accuracy (%)
Laterite exposure	4314	0	15	0	0	0	69	13	0	4411	98	96
Dense forest	0	3755	69	0	4	0	0	4	0	3832	98	95
Open forest	15	154	1336	0	2	0	53	1	0	1561	85	89
Agricultural wet fallow	0	0	0	121	0	0	70	0	0	192	63	100
Agricultural land	0	32	0	0	4404	0	9	0	0	4445	99	99
Water body	14	11	0	0	24	408	8	13	0	478	85	96
Dry fallow	70	0	83	0	6	3	4385	18	0	4565	96	95
Settlement	84	3	0	0	0	12	28	398	0	525	75	89
Sandbar	0	0	0	0	0	0	0	0	1	1	100	100
Column total	4497	3955	1503	121	4440	423	4622	447	0			
Overall accuracy	96 (%)											
Kappa statistics	95 (%)											

Table 7. Land use and Land cover analysis of Garbeta block-1

Land use /land cover class	Area in 1989 in Km²	Percentage of area in 1989	Area in 2000 in Km²	Percentage of Area in 2000	Area in 2018 in Km²	Percentage of area in 2018
Dense forest	55.62	15.01	30.12	8.13	33.255	9.04
Open forest	30.27	8.17	55.39	14.95	34.28	9.25
Agricultural land	31.42	8.48	65.05	17.56	101.24	27.32
Agricultural wet fallow	176.85	47.74	112.16	30.27	64.73	17.47
Dry fallow	48.66	13.14	34.50	9.31	61.22	16.53
Settlement	13.58	3.67	15.1	4.07	16.43	4.43
Water body	5.86	1.58	5.66	1.53	21.62	5.84
Lateritic exposure	6.61	1.78	41.69	11.25	34.24	9.24
Sand bar	1.56	0.42	2.77	0.75	3.15	0.85

Table 8. Areal change of Land use and Land Cover from 1989-2018

Land use land cover class	Area in 1989 in Km²	Percentage of area in 1989	Area in 2000 in Km²	Percentage of Area in 2000	Area in 2018 in Km²	Percentage of area in 2018
Dense forest	55.62	15.01	30.12	8.13	33.255	9.04
Open forest	30.27	8.17	55.39	14.95	34.28	9.25
Agricultural land	31.42	8.48	65.05	17.56	101.24	27.32
Agricultural wet fallow	176.85	47.74	112.16	30.27	64.73	17.47
Dry fallow	48.66	13.14	34.50	9.31	61.22	16.53
Settlement	13.58	3.67	15.1	4.07	16.43	4.43
Water body	5.86	1.58	5.66	1.53	21.62	5.84
Lateritic exposure	6.61	1.78	41.69	11.25	34.24	9.24
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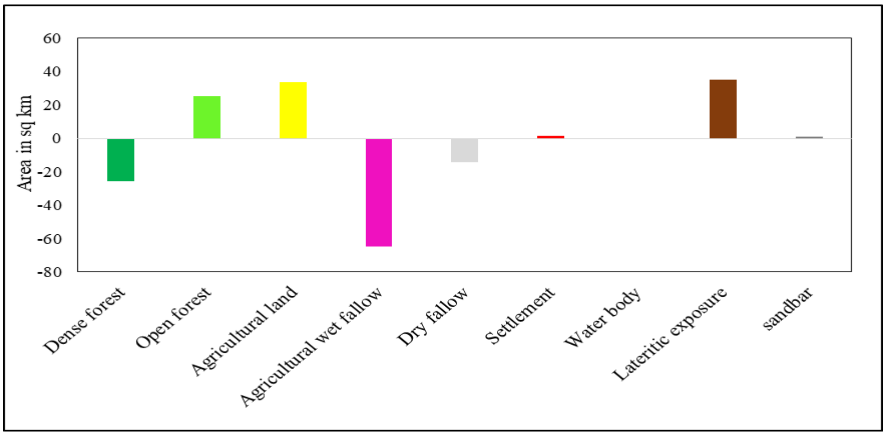
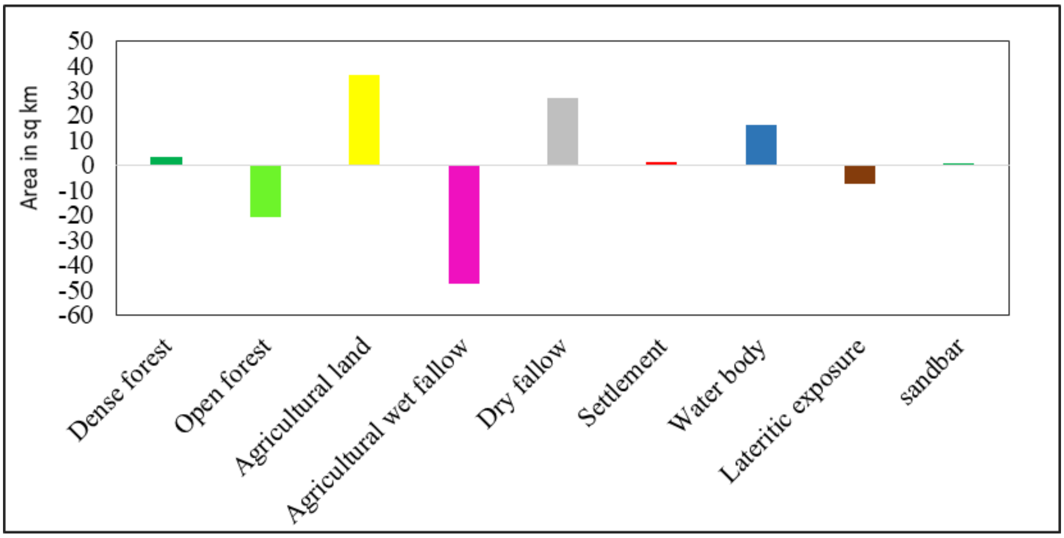


(A)



(B)

Fig. 7. Areal changed between 1989- 2000 (A) and 2000-2018 (B)

Table 9. Land use and land cover conversion table

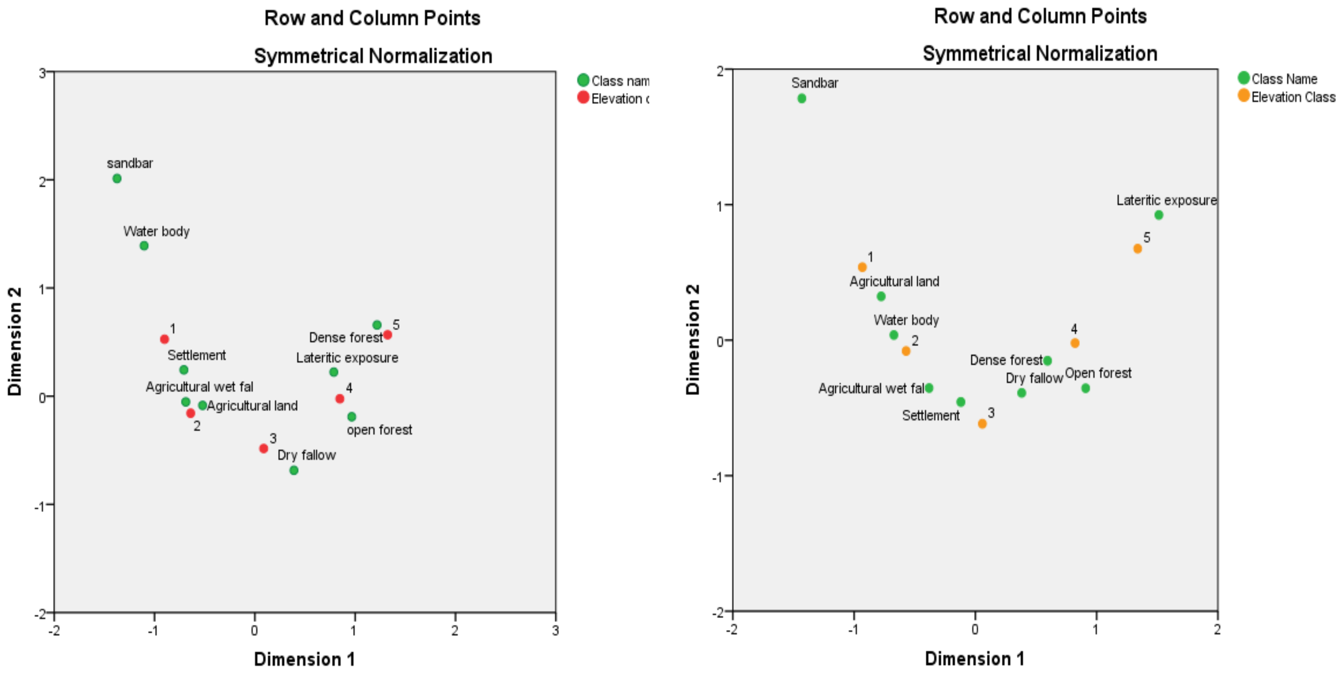
From	To	Area in sq.km (1989 to 2000)	Area in sq.km (2000 to 2018)
Dense forest	Open forest	12.24	5.52
	Agricultural land	4.68	1.85
	Agricultural wet fallow	1.31	1.2
	Dry fallow	3.07	2.18
	Settlement	0.89	1
	Water body	0.07	0.84
	Lateritic exposure	17.28	9.5
	Sandbar	0	0
Open forest	Dense forest	4.56	6.83
	Agricultural land	2.55	3.65
	Agricultural wet fallow	1.31	3.31
	Dry fallow	2.89	16.69
	Settlement	0.54	2.23
	Water body	0.02	1.18
	Lateritic exposure	3.73	8.12
	Sandbar	0	0
Agricultural land	Dense forest	0	5.43
	Open forest	1.68	1.02
	Agricultural wet fallow	15.99	18.37
	Dry fallow	1.80	4.67
	Settlement	0.8	6.64
	Water body	0.15	7.74

	Lateritic exposure	0.28	1.23
	Sandbar	0.06	0.06
Agricultural wet fallow	Dense forest	5.3	1.57
	Open forest	13.77	1.09
	Agricultural land	50.46	53.29
	Dry fallow	5.49	11.58
	Settlement	8.1	4.18
	Water body	1.82	6.63
	Lateritic exposure	10.06	1.12
	Sandbar	1.03	1.11
Dry fallow	Dense forest	1.78	3.49
	Open forest	11.46	4.92
	Agricultural land	1.58	1.49
	Agricultural wet fallow	7.61	5.02
	Settlement	0.24	0.74
	Water body	0.05	0.59
	Lateritic exposure	4.96	1.54
	Sandbar	0.04	0.01
Settlement	Dense forest	0.62	0.99
	Open forest	0.63	0.21
	Agricultural land	5.71	4.67
	Agricultural wet fallow	1.4	0.6
	Dry fallow	0	3.96
	Water body	0.2	1.89
	Lateritic exposure	0.95	0.32
	Sandbar	0	0
Water body	Dense forest	0.04	0.11
	Open forest	0.07	0.01
	Agricultural land	0.7	0.42
	Agricultural wet fallow	0.6	1.58
	Dry fallow	0	0.51
	Settlement	0.42	0.21
	Lateritic exposure	0.26	0.08
	Sandbar	0.57	0.72
Lateritic exposure	Dense forest	1.1	3.49
	Open forest	0.69	4.93
	Agricultural land	0.12	1.49
	Agricultural wet fallow	0.09	5.01
	Dry fallow	0	16.71
	Settlement	0.2	0.74

	Water body	0	0.59
	Sandbar	0	0.01
Sand bar	Dense forest	0	0.03
	Open forest	0	0
	Agricultural land	0	0.05
	Agricultural wet fallow	0.35	0.67
	Dry fallow	0.02	0.33
	Settlement	0	0.03
	Water body	0.14	0.42
	Lateritic exposure	0	0

Table 10. Elevation class of the study area

Elevation in meters	Class	Remarks
23-37	1	Very low
37-46	2	Low
46-56	3	Medium
56-66	4	High
66-83	5	Very high



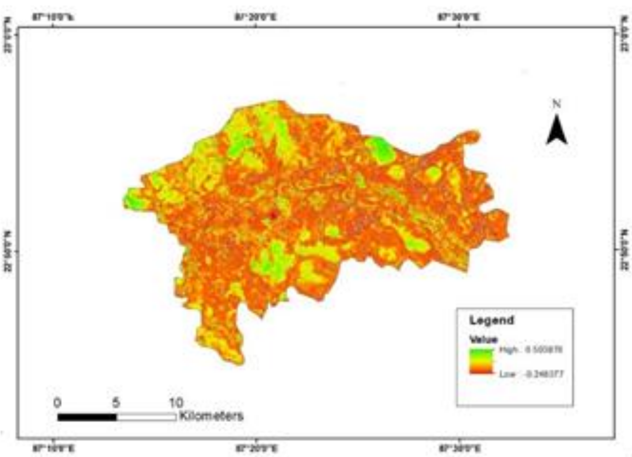
(A) (B)

Fig. 9. The association map between land use/land cover and elevation of 2000 (A) and 2018 (B)

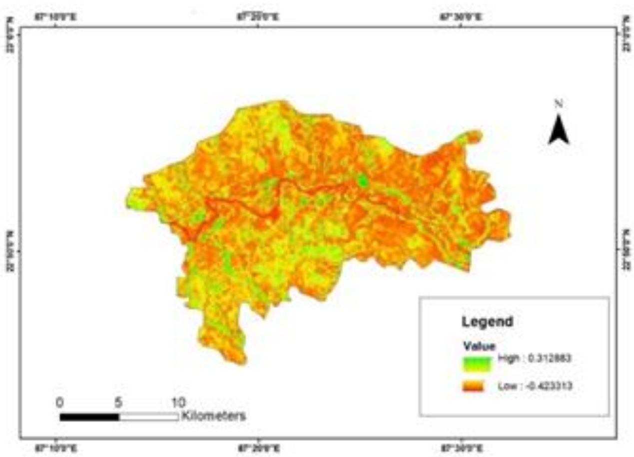
3.5. Environmental Indices:

***3.5.1. Normalized Difference Vegetation Index (NDVI)*:** Normalized Difference Vegetation Index is an important tool in analysing the changes in the forest cover. According to Buma (Buma, 2011: 483) degradation of forest around the world have enough potentiality in modifying the forest cover and composition which in turn can affect the diversity, landscape parameters and carbon storage. The tool has the ability to distinguish the bare soil and vegetation cover. The degradation of the forest cover has fuelled the climatic abnormalities. The forest cover of west Bengal is about 16.847 km² according to the Indian State Forest Report of 2017. Garbeta block of West Medinipore once covered with thick forest of Sal but now effected by human intervention. The NDVI value of the year 1989 was between -0.24 to + 0.50. The areas with values near to 0.50 have high density of vegetation and the land use and land cover map of the same year also shows such trend. In the year 2000 the value ranged between -0.42 to +0.31. The positive value decreased compared to the previous year (1989) which clearly depicts the degradation in the forest area (Figure 10 A, B, C). Again in 2018 the value ranged between -0.35 to 0.40 which signifies an increase in the positive value interpreting a minimal increase in the forest cover which is very much essential in the soil loss over the region. The NDVI map of 2018 shows an even distribution of green coverage as it also includes the green agricultural land which also reflects near infrared lights. According the above land use and land cover maps the percentage of dense forest decreased from 55.62 % in 1989 to 33.26 % in 2018 but there has been a considerable increase in the open forest coverage.

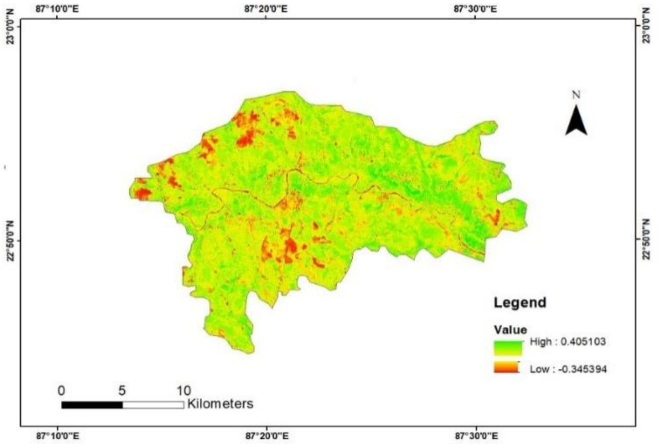
3.5.2. Normalized Difference Water Index (NDWI): Water crisis is going to take a major role in the near future imposing a menace to human life. To cope up with such vulnerability water conservation is at indispensable need. Water scarcity in West Bengal increases with the onset of the summer season. Garbeta of West Medinipore district also suffers from this water scarcity. The ground water level decreases along with the drying up of surface water bodies. The bare lands heats up and moisture content decreases due to high evapotranspiration rate. NDWI can be an important tool in water body mapping. From the NDWI of the three years it can be visualised that areas under moisture content decreased when compared to 2018 with 1989. The value of NDWI of 1989 ranged between –0.45 to + 0.21. In 2000 the positive value increased but the areas of water content decreased. The value ranged between -0.23 to + 0.43. Again in 2018 the areal coverage under moisture content decreased but the value ranged between -0.10 to + 0.49. Further the number of pond in the study area for agricultural propose has been increased. But the main ecological flow of river Shilabati flowing through the region is choked with sedimentation hampering the normal ground water recharge. Thus NDWI can be a useful tool in assessing the water vulnerability over a region and can play an important role in combating drought like conditions.



(A)

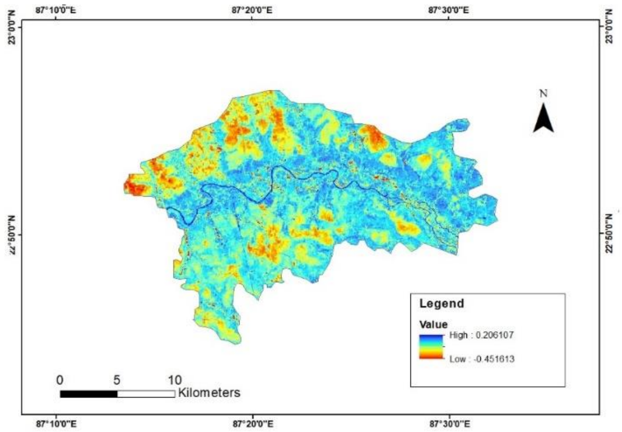


(B)

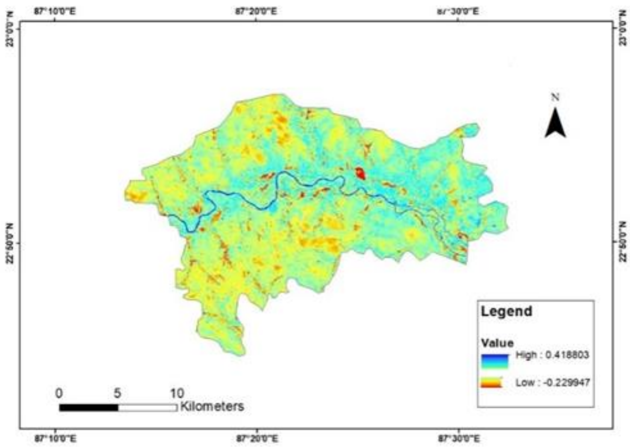


(C)

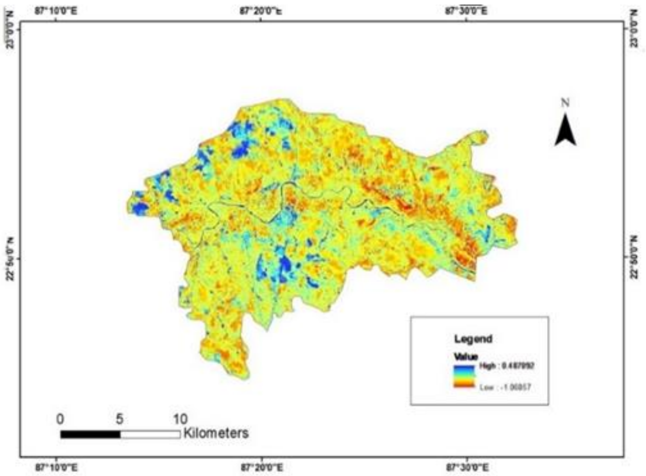
Fig. 10. NDVI map of 1989(A), 2000(B) and 2018(C)



(A)



(B)



(C)

Fig. 11. NDWI map of 1989(A), 2000(B) and 2018(C)

Conclusion

- An assessment of land use and land cover variability has been made using geospatial techniques. The analysis shows a positivity of change in the configuration of these two landform characteristics over the region.
- Garbeta block is located on the lateritic terrain and is highly effected by soil erosion and fluctuation in groundwater recharge is common in dry period. The analysis shows an increase of the percentage of dry fallow over the entire region particularly at the middle of the block making it more vulnerable to environmental hazard.
- The impression of population pressure is clearly seen over the entire region as the percentage of agricultural land has been increased over the recent years which parallely creates demand for irrigational supply. The Shilabati River flowing through the region was also choked with excessive sediment deposition failing to meet the water demand over the catchment area.
- Multiple correspondence analysis clearly shows the association of elevation and landform characteristics over the region. The association between the two parameters has been modified a lot between the years. The Dense forest at the elevation of 66-84m in 2000 has been cleared and can be reflected land use and land cover map of 2018.
- The Normalized Difference Vegetation Index of the study area shows the increase in the green cover but they are mainly green agricultural crops.
- The Normalised difference Water Index of the region shows higher values signifying high water content in the year 1989 but it decreased gradually as the percentage of dry fallow land increased in 2018. These fallow lands are having low moisture content and are exposed to higher rate of soil erosion. As the percentage dry fallow increased in 2018. The water scarcity also increased as most water bodies are reclaimed for various land dwellings.
- This throughout analysis shows the vulnerability of the study area based on environmental and climatic aspects. Remote sensing and GIS can be an important and validate tool to assess such kind of susceptibility as they are time independent. The bare parts needs urgent plantation programme to cope up with the rapid soil loss. Complete environmental, geomorphological, meteorological assessment is further needed over the region to preserve the ecological balance in a sustainable way.

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