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LAND USE/LAND COVER CHANGE ASSESSMENT IN VARUNA RIVER BASIN USING GEOSPATIAL TECHNIQUES

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Abstract - *Every river has its bio- diversity. It is essential to maintain environment balance because besides maintaining water level of the land masses, a river also supports livelihood of people. River Varuna has been rendered severely polluted. In present scenario industrial wastes are emptied into it, along with sewage flowing in from towns in its catchment area has chocked it. Rapid urbanization coupled with lack of proper waste disposal mechanism meant sewage being dumped into the river which has reduced it to a nullah (drain). It is essential to maintain environmental balance because besides maintaining water level of the land masses, a river also supports livelihood of people. The death of a river bereaves us of many such benefits for a healthy and prosperous generation. Drying waterbodies, declining groundwater levels, increasing discharge, declining precipitation has made the situation worst in the basin area which is in consonance with the drought condition prevailing in the basin which has been witnessed by the analysis carried out over a period of few decades (1972-2019) using SOI toposheets and satellite borne data (Sentinel 2B). Decreasing trend of urbanization has given visa to low agriculture land which ultimately has its quantitative depiction of basin geometry and land use pattern.*

***Key Words**:* **Pollution, LULC, Satellite Borne Data, Urbanization**

1.INTRODUCTION

A river is inherently most important commodity in our lives. It carries the essence of a place, its history and its cultural heritage besides sustaining important systems such as agriculture, transportation, pisciculture, industries, recreation and many others. Varuna river has been selected for the study as it has undergone severe dryness. The river is currently facing tremendous pressure due to encroachments, discharge of untreated domestic and industrial waste, dumping of solid waste and illegal diversion of water. Human-induced land use/cover change has been considered to be one of the most important parts of global environmental changes. One half to one third of land use land cover (LULC) has been affected by human activities (Ellis 2011; Vitousek et al. 1997).

Knowledge of land use and land cover is important for many planning and management activities and is considered as an essential element for modelling and understanding the earth as system (Lillesand et al., 2008; Mishra & Rai, 2014; Prajapati, 2016). LULC changes are affected by human interference and natural phenomena such as agriculture, population growth, consumption, patterns, urbanization, economic development etc. As significance, timely and precise information about LULC change detection of the area of interest is tremendously significant for understanding relationships and interactions between human and natural resources for better decision making (Vishwakarma et.al., 2016). Thus, Land use land cover changes (LULC) need monitoring of Earth resources, and advantage greatly from remote sensing data that have the ability to gather enormous amounts of data economically and frequently for huge areas compared to field approaches (Van Lynden & Mantel, 2001). These tools are vital in order to examine the consequences of climate change, whereby land use plays a critical role by inducing the surface-energy budgets as well as the carbon-cycle effects (Pielke et al., 2002).

The change detection frameworks use multi-temporal datasets to qualitatively analyze the temporal effects of phenomena and quantify the changes (Singh, 1989). The RS data has become a major source for temporal change detection studies because of its high temporal frequency, digital format suitable for computation, synoptic view, and wider selection of spatial and spectral resolutions (Lunetta, 2004). The general objectives of change detection in Remote Sensing include identifying the geographical location and type of changes, quantifying the changes, and assessing the accuracy of change detection results (Coppin et al., 2004; Im & Jensen, 2005).

2. DESCRIPTION OF THE STUDY AREA

River Varuna originates at 25°27′N, 82°18′E, at Dain taal Phulpur in Allahabad district and its flow is in east-to-southeast for about 100 km, and joins the Ganga at 25°19′46″N, 83°02′40″E, just downstream of Varanasi city which is one of the prominent industrial, agricultural, and oldest town of Uttar Pradesh state in India, obliging the necessities of several millions of people. River Morwa meets River Varuna at 25°23'38.25"N & 83°41'36.83"E & River Basuhi at different locations 25°23'35.02"N & 82°37'.37"E. Tropical monsoonal climate is knowledgeable about this region. Pre-Monsoon, Monsoon, and post-Monsoon are the major types of seasons in the region. The ambient mean temperature was lowest in December (9.9 to 26.1 °C) and highest in May-June (27.8 to 40.9 °C). The rainy months remained warm and wet, with humidity reaching close to saturation. Location of the study area is shown in Fig – 1.

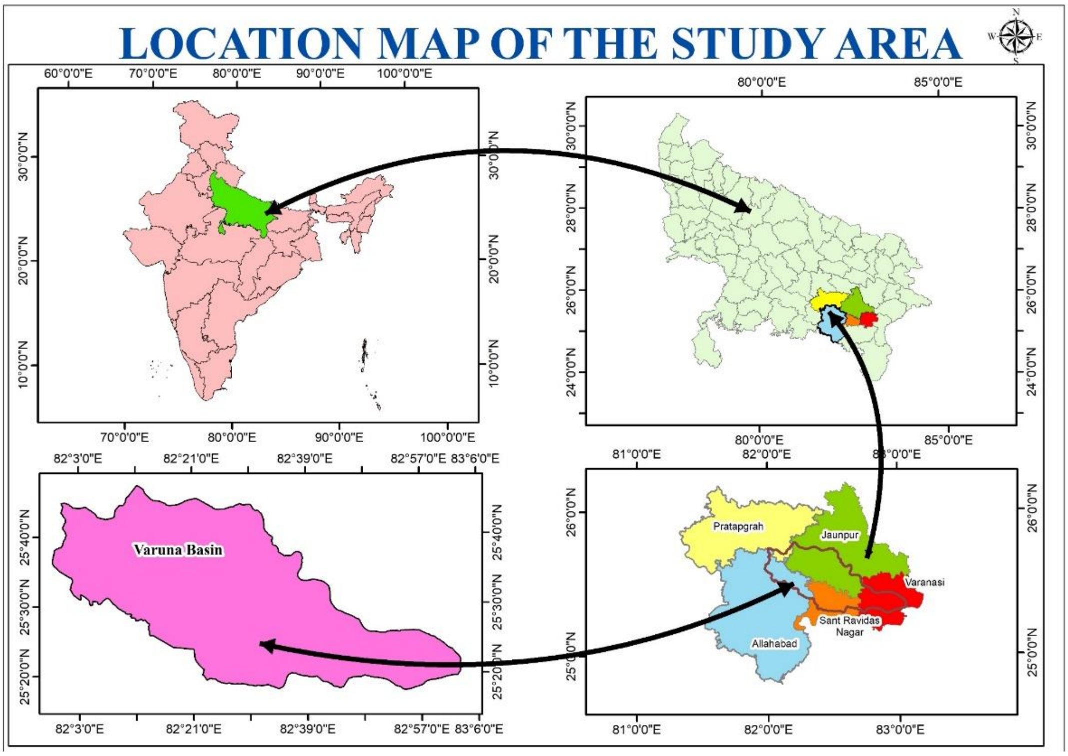

Fig – 1: Location map of Varuna River Basin

Varuna river watersheds height is varying from60m above mean sea level to more than 110 mts above see levels which is shown in figure - 2 maximum part of the basin area experiences 85 to 90 m above mean sea level heights. Overall relief of the basin is gentle.

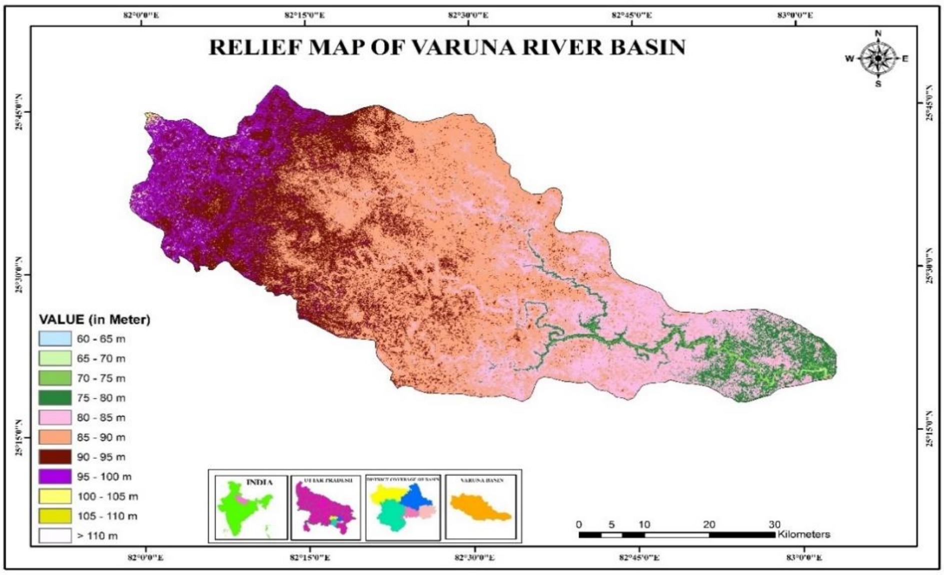

Fig – 2 Relief map of Varuna River Basin

3. DATA USED AND METHODOLOGY

3.1 Data used

For this study, SOI Toposheet of the year 1972 and sentinel satellite data for the 2019 were used for extracting LULC. For the analysis Satellite images free from cloud cover were selected. Basin boundary procured using SOI Toposheet at the scale of 1:50000 and SRTM DEM with 30-meter resolution. Table - 1 and 2 give details of the Satellite and toposheets data used for LULC.

S.NO.	TOPOSHEET NUMBER
1	63G/14
2	63K/2
3	63K/6
4	63K/10
5	63K/3
6	63K/7
7	63K/11
8	63K/15
9	63O/3
10	63K/1

Table – 1 Details of Toposheets

Sr.No.	Sensor	Path-Row	Date of Pass
1	SENTINEL-2B	T44RNP	10-11-2019
2	SENTINEL-2B	T44RPP	20-11-2019
3	SENTINEL-2B	T44RPP	27-11-2019

Table – 2 Details of Satellite Data used

3.2 METHODOLOGY

LULC represents biotic abiotic assets captured by the thematic classifications of the earth's exterior and the environmental circumstance of land areas are stressed, helps for the conservation of water and land resources management in a basin. The data of SOI toposheets for (year 1972) have been used for the LULC. SENTINEL-2 satellite data for the (year 2019) have been used for Land use/Land cover. The methodology used in the study has been represented in the flowchart as shown in Chart - 1

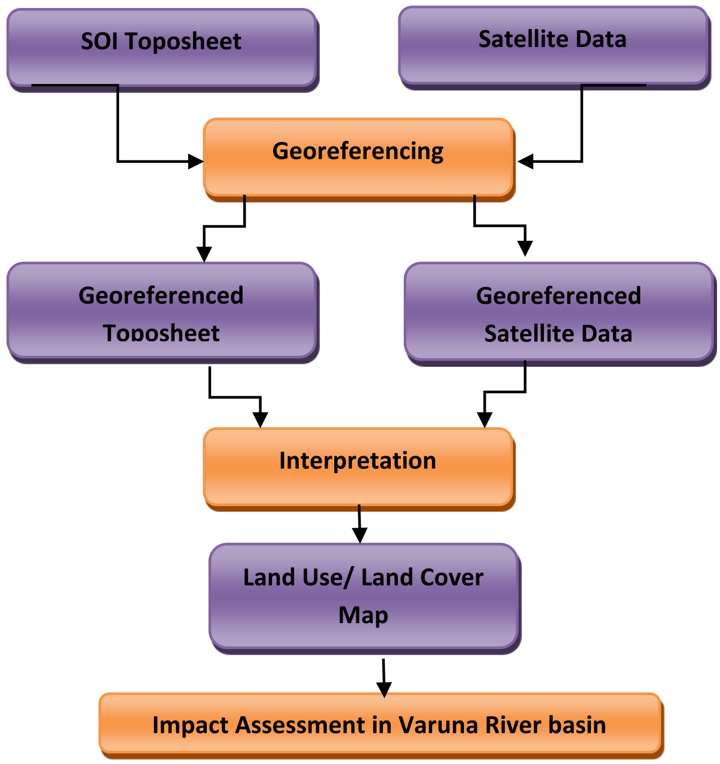

Chart - 1 Research methodology of the study

3. RESULTS

Land use / Land cover has considerable impacts at the watershed level. The maps were generated under different classes in GIS environment using on screen digitization technique was used for the land use land cover map of the year 1972 and supervised classification method is used for the land use land cover map of the study area. By using these techniques data of 1972 and 2019 were classified into Cropland, barren land, scrubland, plantation, settlement and waterbody. There are large scale decreases in the area of waterbody, cropland and barren land classes. On the other hand, significant positive changes are observed in the areas of plantation, scrubland and settlement from 1972 to 2019 as shown in (Table 3). It is interesting to note that the name 'Varanasi' is originated from the name of two rivers, Varuna and Assi. River Varuna at Varanasi is used as a major drainage to carry city sewage underwent drastic changes from 1972 to 2019. The area of Varuna river decreased by 5.605% from 829.577 ha in year 1972 to 783.076 ha in year 2019.

Table 3 gives the statistical results of LU/LC changes. It is evident from the table that the almost 21.7194483 % from 3426.855 ha in year 1972 to 2682.561ha in year 2019 area of the water body has been transgressed between 1972 to 2019. These changes are attributed to eutrophication and increases in the built-up around the river. The decrease of fresh water due to direct use for drinking and other purposes. Unavailability of fresh water puts pressure on ground water. As per report by Ground water board the no of wells increased and depth of ground water level has increases over study area.

Interpretation of satellite data indicates that built-up area is increased considerably up to -584.0925362 % i.e., from 4107.5712 ha in year 1972 to 28099.588 ha in year 2019 area has been transgressed between 1972 to 2019. This urban expansion and population increase has put an adverse effect on agriculture and plantation area and this drastic increase in built-up area is attributed to increase in population over study area.

We also report a decrease of about 39.55679422 % in cropland area from of basin area is slightly decreased from 279489.6462 ha in year 1972 to 168932.502 ha in year 2019. Decrease of cropland is attributed to reduction in waterbodies over study area. Our observation is consistent with a previous study which reported that decline in water caused reduction in cropland area.

Decrease of cropland shows quite increase in barren land area about -1367.370751% from 2827.6992 ha in year 1972 to 41492.831ha in year 2019. Increase of plantation area may lead in overuse of water resource in basin area. In our study we find out that there is small increase in plantation area with -628.2565549% from 3450.3272 ha in year 1972 to 25127.234 in year 2019.

Increase in scrubland leads to shrinking of Varuna river in our study of Varuna river basin we can see that there is large increase in area of scrubland from 1972 to 2019. Scrubland shows change in area about -831.9817167% from 3241.3432 ha in year 1972 to 30208.726 ha in year 2019.

Statistical data of LULC is shown in Table – 3 and Graphical representation of area distribution of LULC is shown in Chart - 2

S.N.	LULC	1972AREA (Ha)	2019AREA (Ha)	Change (1972 - 2019) (in Ha)	% Change from 1972 - 2019 (in Ha)
1	**BARREN LAND**	**2827.6992**	**41492.831**	**-38665.1318**	**-1367.370751**
2	**CROPLAND**	**279489.6462**	**168932.502**	**110557.1442**	**39.55679422**
3	**PLANTATION**	**3450.3272**	**25127.234**	**-21676.9068**	**-628.2565549**
4	**SCRUBLAND**	**3241.3432**	**30208.726**	**-26967.3828**	**-831.9817167**
5	**SETTLEMENT**	**4107.5712**	**28099.588**	**-23992.0168**	**-584.0925362**
6	**WATERBODIES**	**3426.855**	**2682.561**	**744.294**	**21.7194483**

Table - 3 Statistical result of LULC changes

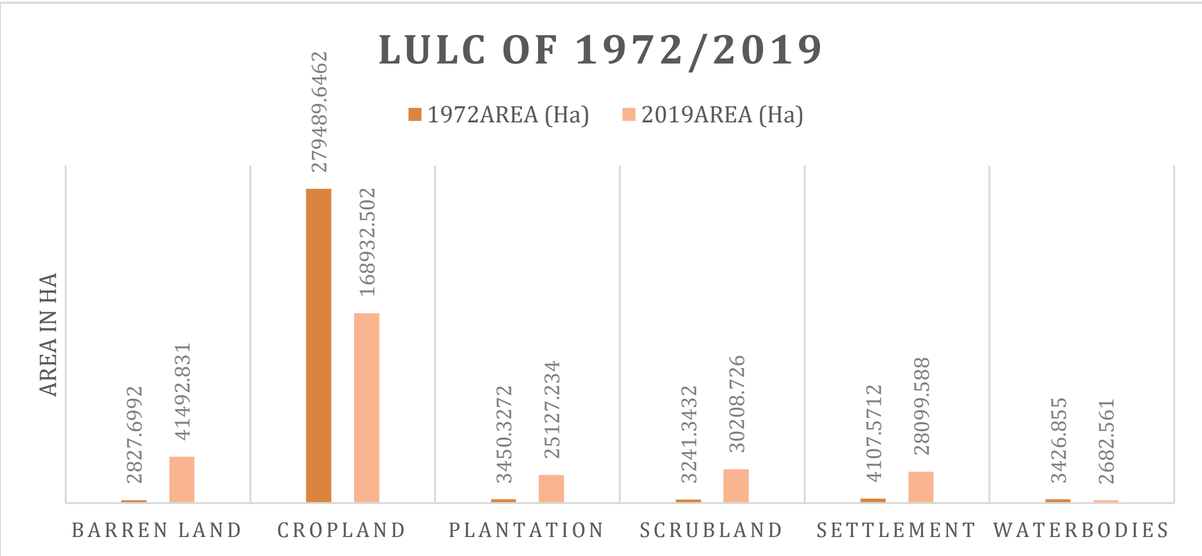

CHART – 2 Graphical representations of area of LULC

LULC map of Varuna river for year 1972 and 2019 can be seen in fig - 5 and fig - 6

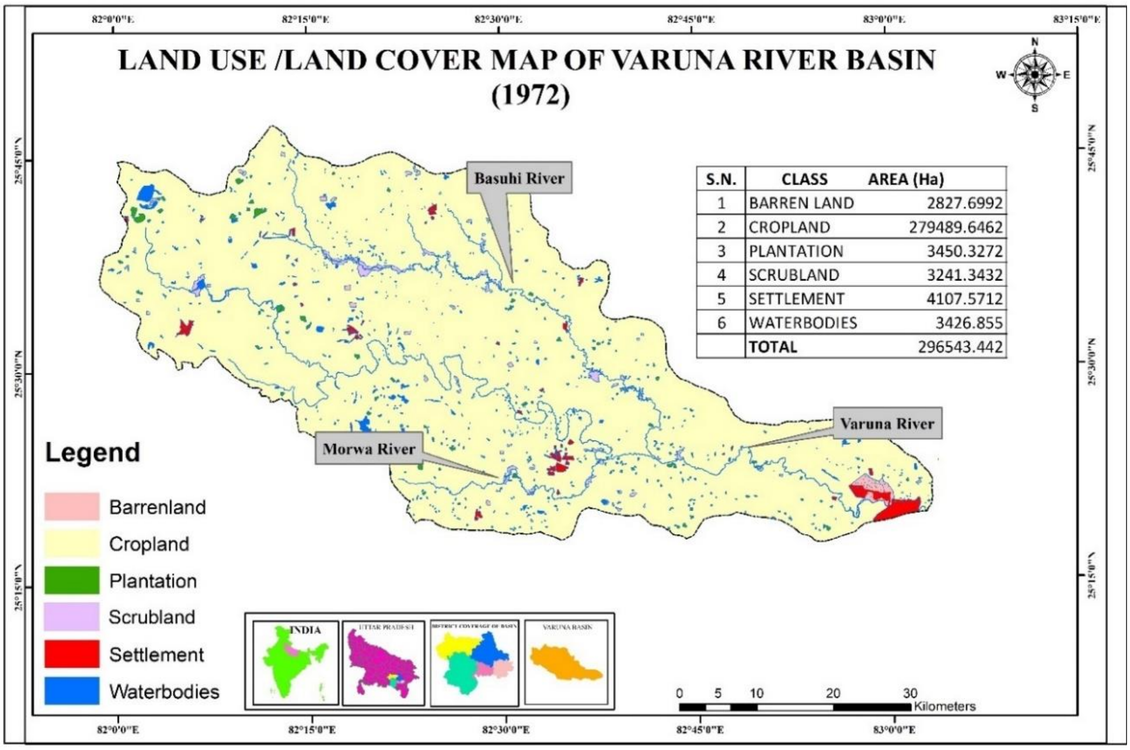

Fig – 5 LULC of Varuna river basin (1972)

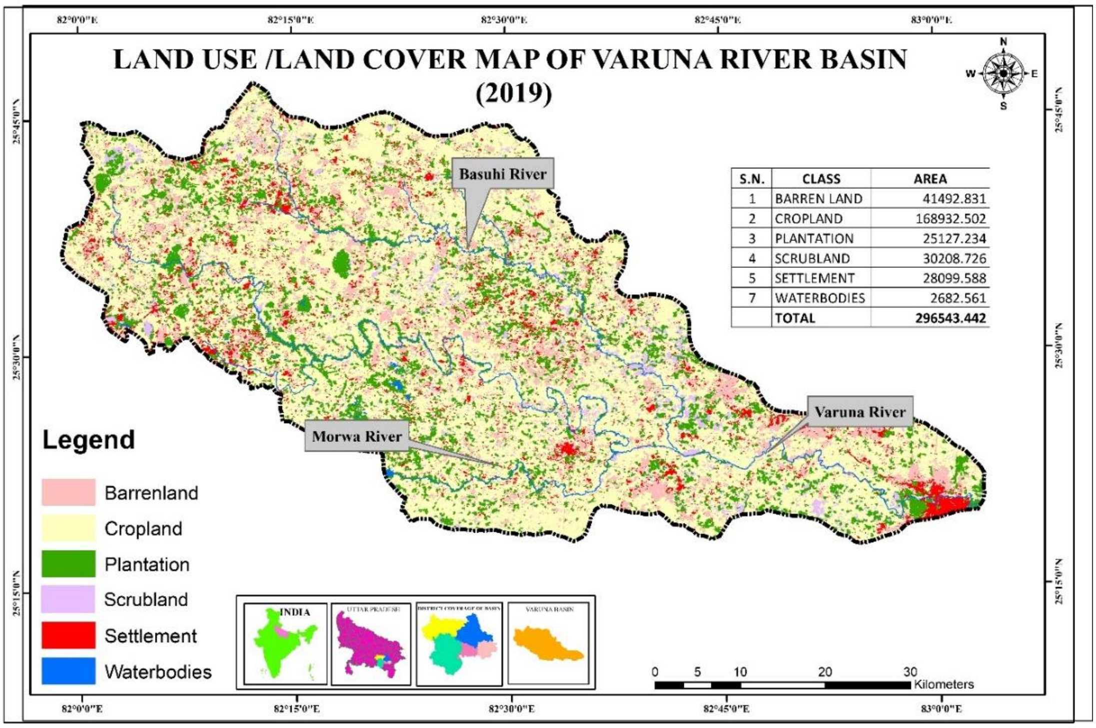

Fig – 6 LULC of Varuna river basin (2019)

Validation with field observation

Table shows error matrix of classified satellite data Sentinel 2 for 2019. The various classes for which error matrix was generated are: Barren land, cropland, plantation, scrubland, Settlement and water body and are depicted in table. Error matrix was calculated using Kappa Statistics, which assess the accuracy of overall classification as well as class wise accuracy.

Kappa statistics is derived below:

$$K = 1 - \frac{nm^2 - \sum_{i=1}^{n}\sum_{j=1}^{k} x_{ij}^2}{nm(m-1)\sum_{j=1}^{k} p_j(1-p_j)}$$

Cohen's kappa coefficient is a statistical measure of inter-rater agreement. Kappa coefficient has three categories 0-0.20 as slight, 0.21-0.40 as fair, 0.41-0.60 as moderate, 0.61-0.80- 1 as almost perfect agreement. Kappa coefficient derived in this study falls in perfect category as shown in Table – 4.

kappa coefficient=86

Sum of diagonals=246

total sum=278

overall accuracy =88

ACCURACY ASSESSMENT TABLE 2019

Classified	Scrubland	Plantation	Cropland	Waterbody	Settlement	Barrenland	Grand total	**Producer Accuracy**
Scrubland	39	1	0	2	0	0	42	92.85714286
Plantation	1	62	3	0	4	0	70	88.57142857
Cropland	2	0	57	0	0	1	60	95
Waterbody	0	0	1	9	0	1	11	81.81818182
Settlement	1	1	7	0	30	1	40	75
Barren land	0	1	2	1	2	49	55	89.09090909
Total producer	43	65	70	12	36	52	278	
Producer Accuracy	91	95	81	75	83	94		

TABLE - 4

5. CONCLUSIONS

The present study incorporates extensive changes in LULC and their linkages with socio-economy over study area. The significant changes in Land use land cover like decrease in cropland area increase in scrubland, barren land and settlement between 1972 to 2019 in terms of loss of natural vegetation cover expansion of urban areas with industrial garbage has given rise to protect river bank erosion, degradation of water resources and water quality. Consistent increase in the area of plantation, includes commercial plantations which is normally the area close to human habitations indicates that plantation increase due to extra commercial plants are planted in these decade. Increase in scrubland and barren land indicates shrinkages in surface water body and reduction of river Varuna. Precipitation patterns are change due to warming over study area. Increase in ground water level over study area may have significant impact on crop production. Significant changes in LULC have distributed the natural ecosystem of study area are causing serious issue to inhabitants.

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