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Detection of Temporal Change and Analysis of Land use and Land Cover: The Case of Area under Durgapur Municipal Corporation in West Bengal

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Abstract : *Today 'land' is a burning issue to the modern world. It is a Natural Capital .Well structured environment is based upon proper utilization of land. It is only possible by applying sustainable land use planning through appropriate implementation of the factors of 'land use optimization' such as resource potential, human potential and environmental potential. By following the way any potential region has to be developed through urbanization process with the governance of local administrative body, state government and central government. It includes different phases of spatial changes. For the purpose of analysis, remote sensing data are used to investigate the land use/land cover change over the last thirty years since 1991 to 2021. The study shows that the notable change has occurred in the last thirty years. Built-up area has increased at higher degree. The main objective of the present paper is to give a comprehensive report of land use change in DMC area. It's aimed at estimating the loss of green patches along with the nature of urban growth. Here, loss of green patches has directly hit the environmental quality which should be maintained at its sustainable level for well-being of the ecological status of an area. Basically the region has been converted into an industrial city from an age old forest clad area through implementation of urban-industrial policy. Initially it was a chance oriented urban expansion. The green cover of the area was sacrificed in the name of industrialization and planned urbanization. Biodiversity loss is a prominent feature in this area thus leading to environmental degradation. Here, an attempt has been made to investigate the problems encountered by DMC and to suggest probable remedies.*

Key words: *Natural capital, land use planning, resource potential, human potential, environmental degradation*

Introduction

'LAND' is an eternal property on which living things can survive. Socio-geographically, land is the basement of civilization. During the starting point of the valley civilization, people were dependent on natural assets mainly on land and water. It is a proven truth that primitive hunting and food gathering were the relevant occupations on which human being survived prior to valley civilization. They were basically pastoral nomads in nature. Gradually people came to know the technique of cultivation .They produced food to run their livelihood. With expansion

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of sedentary firming people started to settle their life in a particular patch of land nearest to the river. Day by day, they practically felt the need of land regularly fertilized by the deposits of flood water. They also observed that land is multi-functional by nature provided that one can utilize it in a systematic manner. The river valleys are the mother-land of virgin flora and fauna. Such a land water relationship has an ecological significance. It maintains the ecological balance of the prevailing ecosystem .Not only that, the floral population or forest is a valuable property existing on the land. Ores containing minerals apart from fossil fuel are the raw materials required for industries. We change in mode of production, forest-oriented livelihood as well as agrarian economy had to provide space for mineral based industrial landscape with paved the way for ecological change, demographic transformation, physico-cultural and social changes leading to urbanization which was experienced by Durgapur, once part and parcel of Jungle Mahals.

Land Resource, Population Dynamics and Sustainability

Land itself is a capital. But utilization of capital (or land) is very important. Different economic geographers have taught us the functionality and dynamic nature of the land resources. It completely depends on the utilization. But here, only important thing is –how can one utilize the things and how far is it friendly with the environment and its surroundings? Because today protection of environment is an important issue that is why proper utilization of land should be maintained. Land has two distinct characteristics, one of them is economic applicability and another one is eco-friendly nature. Now a days, world is very fast–moving. The dynamic nature of scientific man always tries to maximize the resource utilization without any care for sustainable environment. Ultimately it turns into abuse of resources. Optimum use of resources implies proper interaction between resource potential, human innovation and environmental potential of an area. But, it is very common in spatial extent in terms of the socio-economic development that occurs sporadically. Very recently environmental approach in resource creation teaches the need of proper planning for the development process to achieve the sustainable goals for an area. Here, environmental potential of an area should be highly acknowledged because its degradation costs a lot. It is a continuous attribute of the land which cannot be separated by the boundary of any region. Natural environment has the fixed capacity to hold the living things in a proper ecological and sustainable way.

In Durgapur, the change in population size is a significant variable for determining the land use and land cover change. Table1 shows the demographic profile of the study area. The population size and its growth pattern along with population density have been incorporated in the table since 1961 to 2021. The changing pattern of population figure and its growth pattern are expressed in graphs. The demographic pattern of Durgapur municipal corporation area shows an abnormal scenario. Specially, the growth rate of the year 1961-1971 reveals an abrupt high figure which is 395.58% followed by 50.89% in 1971-81,36.57% in1981-91,15.87% in1991-2001 and 14.21% in 2001-2011 respectively. In this context, it is very clear that, socio-economic condition of the study area supports the enhancement of the growth rate of population. Actually, the study

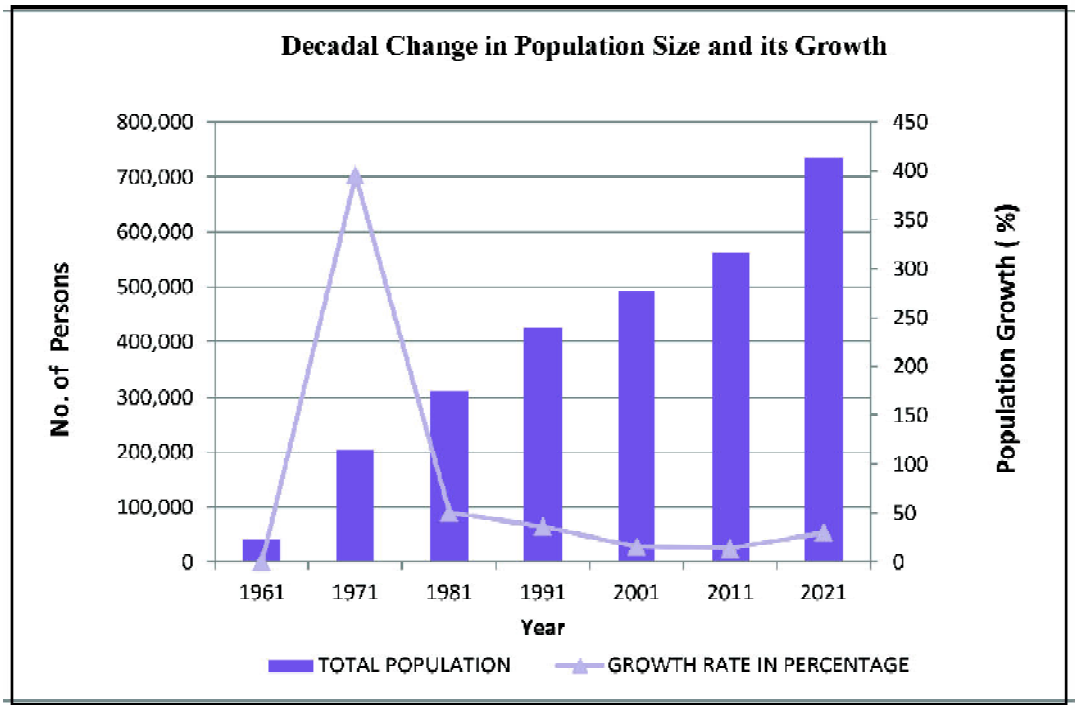
area had been developed as an industrial town. It was the manifestation of 2nd five years plan in the year 1955-56 where the main thrust was on heavy industry. In that regard, for the state of West Bengal, Durgapur-Asansol belt had been chosen as an industrial region. Industrial growth pulled many people from the different part of the country to satisfy the demand of industrial needs. That is why population growth chart shows an abnormal population growth in the year of 1971 in Durgapur. After the couple of decades, population growth rates were not at that higher level but still the figures were higher. Moreover, other supplementary subsequent development process was activated over this region, which was the part of post-industrial activity. In that connection, 1971 onwards, the region had gone through a series of urbanization effort. It is the supportive reason responsible for population growth. According to 2001and 2011 census, the growth rate of population had more or less uniform, because the last 20-25 years, the area had gone through a mature stage in view of simultaneous industrial development process. In the meantime many industries became sick, for this reason, no remarkable population inflow had been observed. Many people had left the city after their retirement or break of service. But normal population growth had taken place. As a result of this, a symmetrical trend of the growth rate of population has been detected.

Table1: Demographic Profile of the Study Area, 1961-2021

Census Year	Area in sq. km	Total Population	Population Density/sq.km.	Growth rate in percentage
1961	73.69	41,691	566	-
1971	154.20	2,06,638	1340	395.58
1981	154.20	3,11,798	2022	50.8
1991	154.20	4,25,836	2763	36
2001	154.20	4,93,405	3200	15.
2011	154.20	5,66,517	3655	14.2
2021 (Projected)	154.20	7,36,000	4773	30.60

Data Source: Census of India

In the present world, population explosion is a burning issue. According to the Malthusian theory, population growth occurred in Geometric Progression (GP) but production of crops increases in Arithmetic Progression (AP). That means, available land is not sufficient to satisfy the demand of growing population in terms of their food, shelter and land oriented demand. The human being becomes greedier for their economic development. The process of lop sided development ultimately brings curse for them. Desire for betterment forced them to break the land and build the new world. In this way, the abuse of land and surroundings completely destroy the physical environment in a land oriented feudal production system where mono cropping was the order.



Naturally today's world is totally different from the previous one regarding its physical, cultural, ecological, socio-economic, and political aspects. But in the meantime, intellectual section has whole heartedly realized that, what a dangerous future is standing in front of them! They felt that forthcoming situation will force them to face the music of uncertain future. Capitalist mode of production changed the situation entirely because of switch over from land oriented to factory oriented production system based on minerals. The environment is said to be sustainable when its spatial pattern is accompanied with its healthy ecological nature. Since most of the land use and land cover changes are directly influenced by human activities, they rarely follow standard ecological theories (Partha Sarathi Roy and Arijit Roy,2010). They excavated different minerals, construct roads, railways, buildings and other infrastructures by sacrificing vegetal cover leading to destruction of natural environment. During past few decades, nature landscape was degraded and polluted. Over the last few decades, agro-based industrial expansion in Bangladesh has a major effect on LULC of the surrounding areas of that neighboring country. The immense changes in Land use and Land cover influence ecosystem, life and livelihoods (Hosen Md Sabbir, et.al, 2021). The imbalance between land use and land cover has caused environmental problems in Katingan Regency of Indonesia (Iskandar Beni, et.al, 2023). It is only because of unplanned and over use of resources which mainly includes land resources. But to get optimum use of land one should apply a proper method or technique for the land utilization of a particular area. Land

use planning is such a scientific methodical process which can be able to do the land use optimization by tackling the complex interplay of environmental parameters, economic needs and social well-being of the society concerned. Land use planning is also a guideline of an area that can create a sustainable path to exercise its land potential, human resources and ecological aspects. It is such a method that can establish a balance between physical and socio-economic environment. Through land use planning, the sustainable development and proper social growth can be achieved. But statistics tells us that before 20 th century, when modern development strategy was initiated in India, it was basically chance oriented. This was true for any place in rural or urban areas, towns or cities excluding modern planned city. So land use planning can be able to build a Sustainable Morphological Structure of an area which is only for welfare of the people. Durgapur Municipal Corporation area is such a place where the process of industrialization and urbanization was started on a chance basis where huge vegetal cover of *Jangal Mahal* was sacrificed. By the passage of time the area was growing with a large volume of population associated with huge urban expansion. As a result, socio-economic and environmental problems emerged as major issues related with urban morphology. In this connection, accurate analysis of land use and land cover is essential for the selection, planning and implementation of land use programs of an area to meet the growing demand of the people. The proper information generated from the analysis is important to mitigate the problems faced by the study area and to establish the sustainable environment for welfare of the people. In this connection, LULC analysis is more relevant in determining the real situation of the area. Land cover age refers to the temporal information associated with different land cover types in an area. It helps to study landscape dynamics, monitor land use changes and evaluate environmental impacts (Boonprong Sornkitja and Kantachawana Anak,2023). Here, an attempt has been made to study the changing pattern of land use and land cover by satellite image classifications in Durgapur Municipal Corporation (DMC) Area.

Objectives of the study

The present study has been taken up to fulfill the following objectives:

i) To identify the changing pattern of land use/land cover of the study area

ii) To analyze the amount of change over the time of thirty years

iii) To estimate the loss of green cover leading to environmental degradation and squeezing of biodiversity base

iv) To suggest suitable measures to prevent environmental degradation

Materials and Methods

There are several stages for application of methods applied in order to fulfill the objectives. In the initial phase literature survey was conducted and base map was prepared. A survey schedule along with target oriented questionnaires was also prepared. Intensive field survey was taken up

across all 43 wards of DMC to observe the processes of transformation. Visual tools were also utilized to illustrate spatio-temporal variations supported by photographs. Interviews with residents have been transformed into primary data base providing insights into their perceptions on urban developments and infrastructural issues. Purposive sampling technique was adopted with a sample size of 645 covering intersection of the urban population. Satellite data were derived from USGS Earth Explorer as depicted in the table 2.

Table 2: Major information of Satellite Images utilized

Year	Acquisition Date	Satellite	Sensor	Path/Row	Resolution (m)	Projection
1991	24-01-1991	Landsat 5	TM	139/44	30	UTM-WGS84
2001	19-01-2001	Landsat 5	TM	139/44	30	UTM-WGS84
2011	31-01-2011	Landsat 5	TM	139/44	30	UTM-WGS84
2021	10-01-2021	Landsat 8	OLI/TIRS	139/44	30	UTM-WGS84

Data Source: *USGS Earth explorer*

StudyArea:

The area is situated in between the parallels of latitude of 23 27’15" N -23 37’ 45" N and the meridians of longitude of 87 12’ 30" E -87 26’30"E. It has grown up over an area of 154.2 Sq. Km. consisting of 43 wards where some wards are insignificant villages. It is situated only 65 Km. away in the western part of the districts headquarters, Burdwan. Kolkata, the capital of West Bengal and the International city with airport, river port, and dock on the River Ganges, is found 170 Km. away on the railway in the east of Durgapur. The famous coal field of Ranigunj stands only 15 Km. away in the west of the area. Asansol, an old but well known industrial town of West Bengal and one of the important Divisional headquarter of the Indian Railway, is found only 25 Km away in the west of DMC area. Kazi Nazrul Islam Airport, Andal is situated about 18 Km. away via NH 19 in the west of the area. The river Damodar flows along the southern front of the area.

Result and Discussion

For the purpose of the study, four decadal satellite images are classified to identify the land use land cover change pattern. Then percentages of areas are calculated under different classes to get a comprehensive idea about the level of anthropogenic activity in the study area. All results and related interpretation are given in details.

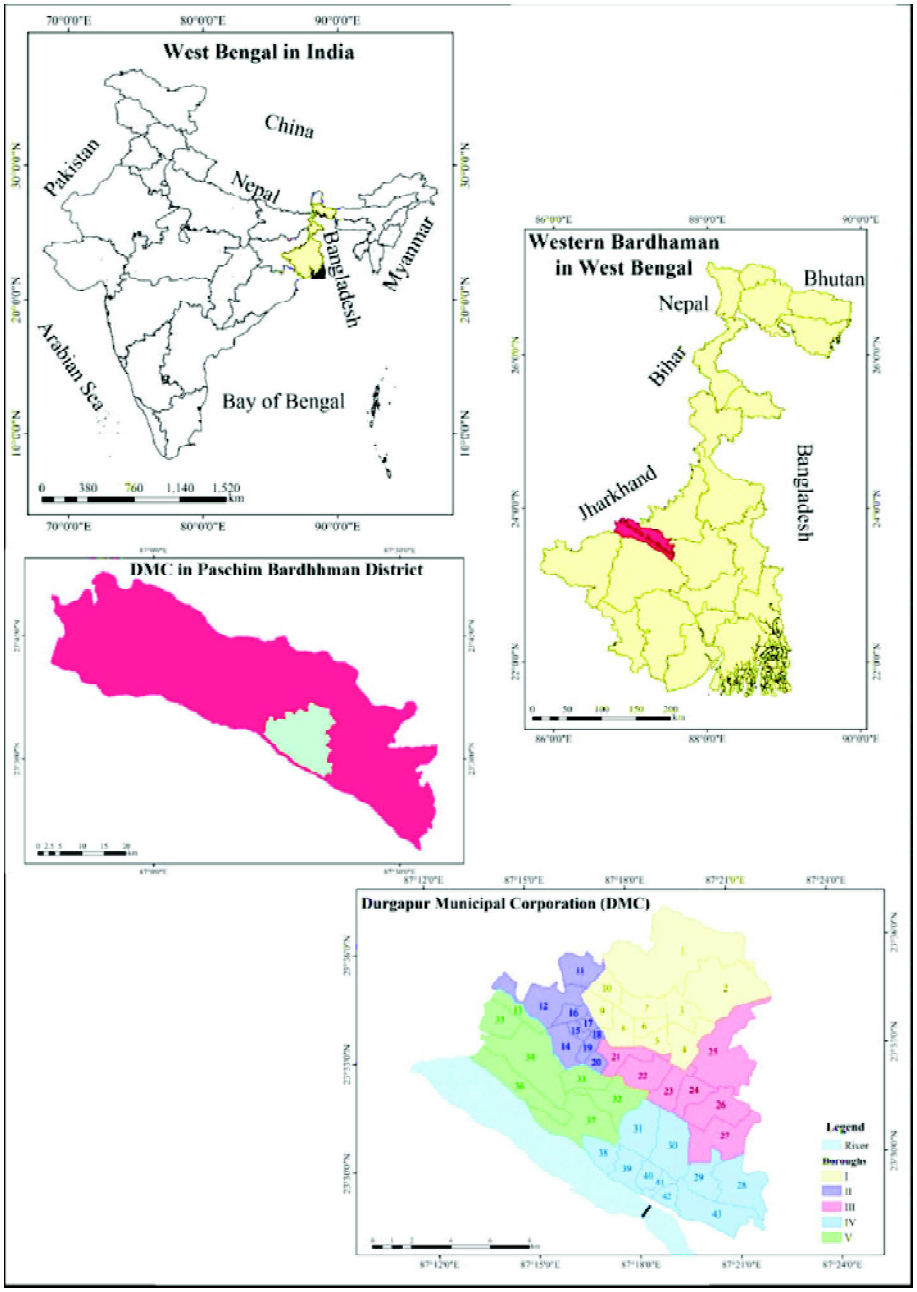
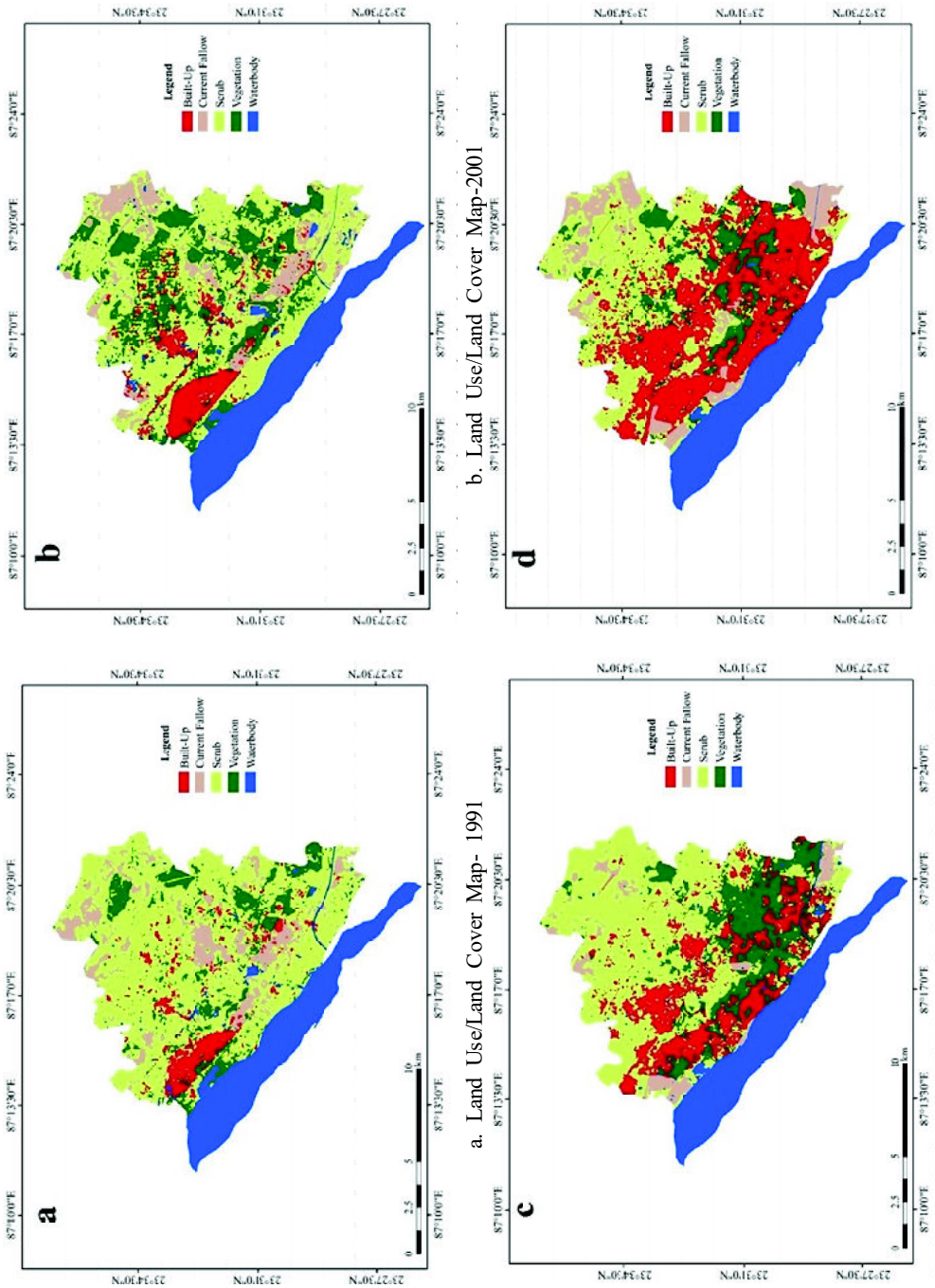


Figure 1. Location of the Study Area

Source: *Survey of India and Govt. of West Bengal*



a. Land Use/Land Cover Map- 1991

b. Land Use/Land Cover Map-2001

c. Land Use/Land Cover Map-2011

d. Land Use/Land Cover Map-2021

Source: USGS Earth Explorer

Figure 2. Temporal Change in Land Use and Land Cover of Durgapur City

Discussion

The dataset provides an overview of land use and land cover changes in Durgapur Municipal Corporation from 1991 to 2021. Vegetation area increased significantly from 18.47 sq. km in 1991 to 35.70 sq. km in 2001 but then declined to 21.10 sq. km by 2021, indicating initial afforestation efforts followed by urban encroachment. Current fallow land experienced fluctuations, marginally increasing from 20.44 sq. km in 1991 to 21.60 sq. km in 2001, dropping to 9.26 sq. km in 2011, and rising again to 17.61 sq. km by 2021, reflecting changes in agricultural area and land availability. Scrub land decreased from 97.26 sq. km in 1991 to 72.74 sq. km in 2001, slightly rose to 77.15 sq. km in 2011, and then fell to 53.95 sq. km by 2021, suggesting land reclamation for other uses. Water body areas diminished from 3.81 sq. km in 1991 to 1.09 sq. km by 2021, pointing to water management challenges and encroachment. The built-up area showed a substantial increase from 10.61 sq. km in 1991 to 56.85 sq. km by 2021, highlighting rapid urbanization and infrastructure development. Overall, the computed data reflect significant urban expansion at the expense of natural land cover, driven by population growth and economic development in Durgapur.

Table 3: Decadal changes in percentage of Land use and Land cover in Durgapur City

Class Name	1991 (sq.km)	%	2001 (sq.km)	%	2011 (sq.km)	%	2021 (sq.km)
Vegetation	18.47	12.27	35.70	23.71	30.59	20.30	21.10
Current Fallow	20.44	13.58	21.60	14.35	9.26	6.14	17.61
Scrub	97.26	64.58	72.74	48.32	77.15	51.21	53.95
Water body	3.81	2.53	5.02	3.33	2.23	1.48	1.09
Built-Up	10.61	7.05	15.48	10.28	31.42	20.86	56.85
Grand Total	**150.59**		**150.59**		**150.59**		**150.59**

Nature of changes:

As per Table3, the dataset provides insights into the changes in land use and land cover for Durgapur Municipal Corporation from 1991 to 2021. Vegetal cover reflected a notable increase of 17.22 sq. km between 1991 and 2001, followed by decrease of 5.11 sq. km from 2001 to 2011 and 9.49 sq. km from 2011 to 2021, resulting in an overall modest increase of 2.62 sq. km over the entire period. Current fallow land experienced a slight increase of 1.16 sq. km from 1991 to 2001, a significant decrease of 12.34 sq. km from 2001 to 2011, and then an increase of 8.35 sq. km from 2011 to 2021, cumulatively decreasing by 2.84 sq. km. Scrub land decreased substantially by 24.52 sq. km from 1991 to 2001, increased by 4.41 sq. km from 2001 to 2011, and then decreased again by 23.20 sq. km from 2011 to 2021, totaling a net decrease of 43.31 sq. km over the three decades. Water body areas increased by 1.21 sq. km from 1991 to 2001 but then decreased by 2.78 sq. km

from 2001 to 2011 and 1.15 sq. km from 2011 to 2021, resulting in an overall decrease of 2.72 sq. km. Built-up areas consistently increased across all periods, with gains of 4.87 sq. km from 1991 to 2001, 15.94 sq. km from 2001 to 2011, and 25.44 sq. km from 2011 to 2021, leading to a significant overall increase of 46.24 sq. km. Overall, the computed data set reflect significant urban expansion at the expense of natural land covers, driven by population growth and economic development in Durgapur.

Table 4: Decadal Changes in Land cover and Land use in Durgapur City

Class Name	Positive and Negative Changes in Sq. Km.			
	1991-2001	2001-2011	2011-2021	1991-2021
Vegetation	17.22	-5.11	-9.49	2.62
Current Fallow	1.16	-12.34	8.35	-2.84
Scrub	-24.52	4.41	-23.20	-43.31
Waterbody	1.21	-2.78	-1.15	-2.72
Built-Up	4.87	15.94	25.44	46.24

Data Source: USGS Earth Explorer

Percentage of changes:

The dataset in Table 4 provides insight into the percentage changes in land use and land cover for Durgapur Municipal Corporation from 1991 to 2021. Vegetal cover revealed a significant increase of 93.23% from 1991 to 2001, followed by decline of 14.32% from 2001 to 2011 and 31.03% from 2011 to 2021, resulting in an overall increase of 12.43% over the entire period. Current fallow land increased by 5.66% from 1991 to 2001, sharply decreased by 57.14% from 2001 to 2011, and significantly increased by 90.22% from 2011 to 2021, culminating in a net decrease of 16.10% from 1991 to 2021. Scrub land decreased by 25.21% from 1991 to 2001, increased slightly by 6.06% from 2001 to 2011, and decreased again by 30.08% from 2011 to 2021, leading to a cumulative decrease of 80.29%. Water body areas increased by 31.85% from 1991 to 2001, then sharply decreased by 55.46% from 2001 to 2011 and by 51.40% from 2011 to 2021, resulting in a significant overall decrease of 250.41%. Built-up areas showed consistent and substantial increase, 45.87% from 1991 to 2001, 102.99% from 2001 to 2011, and 80.96% from 2011 to 2021, with an overall increase of 81.34% from 1991 to 2021. These trends reflect significant urban expansion at the expense of natural land covers, driven by population growth and economic development in Durgapur.

Decadal rate of changes:

As per Table5 the dataset reveals the annual rate of change in land use and land cover for Durgapur Municipal Corporation from 1991 to 2021. Vegetation experienced an annual increase of

Table5: Percentage of Changes in Land cover and Land Use in Durgapur City

Class Name	Percentage of changes			
	1991-2001	2001-2011	2011-2021	1991-2021
Vegetation	93.23	-14.32	-31.03	12.43
Current Fallow	5.66	-57.14	90.22	-16.10
Scrub	-25.21	6.06	-30.08	-80.29
Water body	31.85	-55.46	-51.40	-250.41
Built-Up	45.87	102.99	80.96	81.34

Data Source: USGS Earth Explorer

1.72 sq. km/year from 1991 to 2001, followed by decreases of 0.51 sq. km/year from 2001 to 2011 and 0.95 sq. km/year from 2011 to 2021, resulting in an overall modest annual increase of 0.26 sq. km/year. Current fallow land experienced a slight annual increase of 0.12 sq. km/year from 1991 to 2001, a significant annual decrease of 1.23 sq. km/year from 2001 to 2011, and an annual increase of 0.84 sq. km/year from 2011 to 2021, leading to a net annual decrease of 0.28 sq. km/year. Scrub land decreased at an annual rate of 2.45 sq. km/year from 1991 to 2001, increased slightly by 0.44 sq. km/year from 2001 to 2011, and decreased again by 2.32 sq. km/year from 2011 to 2021, resulting in a cumulative annual decrease of 4.33 sq. km/year. Water body areas increased by 0.12 sq. km/year from 1991 to 2001, then decreased by 0.28 sq. km/year from 2001 to 2011 and 0.11 sq. km/year from 2011 to 2021, culminating in an overall annual decrease of 0.27 sq. km/year. Built-up areas depicted consistent and substantial annual increase, 0.49 sq. km/year from 1991 to 2001, 1.59 sq. km/year from 2001 to 2011, and 2.54 sq. km/year from 2011 to 2021, with an overall annual increase of 4.62 sq. km/year. These trends highlight significant urban expansion at the expense of natural land covers, driven by population growth and economic development in Durgapur.

Table 6: Annual changes in Land cover and Land use in Durgapur City

Positive and Negative changes in Land cover and Land use				
Class Name	1991-2001	2001-2011	2011-2021	1991-2021
Vegetation	1.72	-0.51	-0.95	0.26
Current Fallow	0.12	-1.23	0.84	-0.28
Scrub	-2.45	0.44	-2.32	-4.33
Water body	0.12	-0.28	-0.11	-0.27
Built-Up	0.49	1.59	2.54	4.62

Data Source: USGS Earth Explorer

The dataset of Table-6 examining land use and land cover information of Durgapur Municipal Corporation from 1991 to 2021 provides a comprehensive understanding of the significant shifts in various land cover classes over time. Across the decades, vegetal covers witnessed notable fluctuations, initially experiencing a substantial increase from 1991 to 2001 before gradually declining. Conversely, current fallow land exhibited a more erratic pattern, fluctuating between stability and sharp decreases, indicating changing agricultural areas and land availability. Scrubland, dominant in 1991, decreased steadily over the years, while built-up areas consistently expanded, reflecting rapid urbanization and infrastructure development. Water bodies reflected minor fluctuations but an overall decrease, likely influenced by water management challenges and encroachment. These findings collectively underscore the narrative of urban expansion at the expense of different categories of land covers in Durgapur, driven by population growth and economic development. In summary, the dataset provides insight into the changing landscape of Durgapur Municipal Corporation, revealing trends in land use and land cover dynamics over three decades. Notable observations include the increase and subsequent decline of vegetation, fluctuations in current fallow land, steady decreases in scrubland, and consistent expansion of built-up areas. These trends revealed the complex interplay between urban development and environmental conservation, highlighting the importance of informed land use planning to ensure sustainable growth and preserve ecological integrity in rapidly developing regions like Durgapur.

Table 7: LULC Transition Matrix from 1991-2021, the case of Durgapur City

Year	2021 Area (Sq. km)						
1991 Area (Sq. Km)	**LULC Class**	**Built-Up**	**Current Fallow**	**Scrub**	**Vegetation**	**Water body**	**Grand Total**
	Built-Up	7.42	1.29	1.24	0.64	0.02	10.61
	Current Fallow	7.03	4.36	6.41	2.60	0.01	20.42
	Scrub	37.49	10.02	39.81	9.69	0.12	97.12
	Vegetation	3.42	1.37	5.91	7.61	0.13	18.44
	Water body	1.45	0.52	0.48	0.53	0.80	3.79
	Grand Total	**56.81**	**17.56**	**53.85**	**21.08**	**1.08**	**150.38**

Data Source: USGS Earth Explore

Transition Matrix

As per Table7 the land use transition matrix from 1991 to 2021 shows how different categories of land have changed over last three decades. From 1991, 7.42 sq. km of Built-Up land remained unchanged till 2021, while 1.29 sq. km converted to Current Fallow, 1.24 sq. km to Scrub, 0.64 sq. km to Vegetation, and 0.02 sq. km to Water body. Current Fallow land, initially covering 20.42 sq.

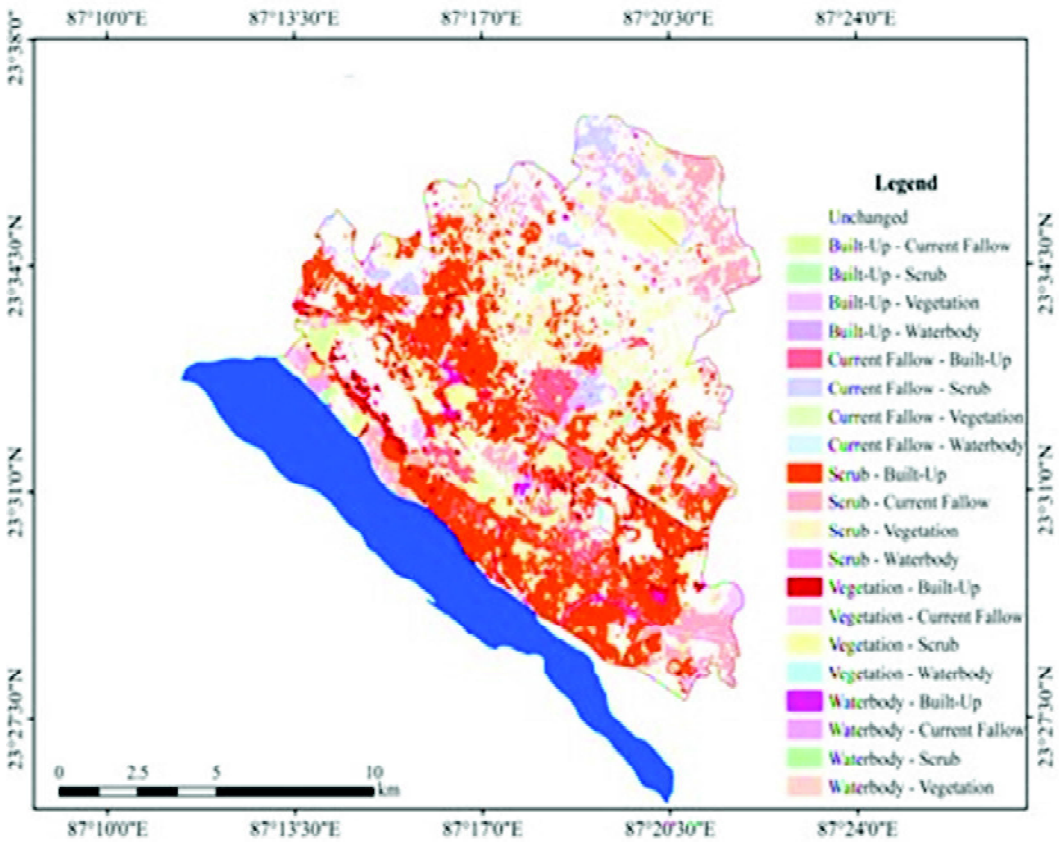


Figure 3. LULC Transition Map of Durgapur Municipal Corporation from 1991-2021

Source: USGS Earth Explorer

km, experienced 7.03 sq. km transition to Built-Up, 4.36 sq. km remain unchanged, 6.41 sq. km change to Scrub, 2.60 sq. km to Vegetation, and 0.01 sq. km to Water body. Scrub land underwent the most significant transition, with 37.49 sq. km becoming Built-up area, 10.02 sq. km converting to Current Fallow, 39.81 sq. km remaining Scrub, 9.69 sq. km turning into Vegetation, and 0.12 sq. km becoming Water body. Vegetation areas also witnessed notable changes, 3.42 sq. km turned into Built-up area, 1.37 sq. km into Current Fallow, 5.91 sq. km into Scrub, 7.61 sq. km remained area under Vegetation, and 0.13 sq. km converted to water body. Area under water body, the most stable one, had 0.80 sq. km unchanged, while 1.45 sq. km became Built-up area, 0.52 sq. km turned into Current Fallow, 0.48 sq. km changed to Scrub, and 0.53 sq. km transformed to area under vegetal cover. In totality, the land area analyzed was 150.38 sq. km, reflecting significant land use changes over three decades.

Conclusion

Land use and Land cover change is the reflection of anthropogenic activities acting on the spatial level. Industrial expansion and growth of urban infrastructure are the main drivers of land cover change. Escalation in the population size needs more and more service for their survival leading to further spatio-structural expansion. In case of Durgapur, process of industrial urbanisation is the main reason behind Land use and Land cover change. Temporal change map clearly shows that, many scrub land, vegetation; fallow lands are sacrificed for the need of industrial and urban expansion. As a result, environmental degradation in terms of deterioration in air and water quality, different types of health related problem of the dwellers, biodiversity loss are very common scenario in this region. This land cover change is an irreversible phenomenon. Transition matrix is a useful tool to measure the actual quantity under different classes and their changes. It reveals a massive expansion of built-up area. In this respect, a sustainable land use planning is expected to help us for arresting unmanageable expansion of urban infrastructure by adopting appropriate steps for conservation of green patches and water bodies along with prevailing biodiversity and control on atmospheric as well as water pollution.

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