IJFANS INTERNATIONAL JOURNAL OF FOOD AND NUTRITIONAL SCIENCES
ISSN PRINT 2319 1775 Online 2320 7876
Research paper UGC CARE Listed (Group -I) Journal Volume 11, Iss 10, Dec 2022

LAND USE AND LAND COVER DYNAMICS IN THE SINA RIVER BASIN: A DECADAL ANALYSIS USING LAND CHANGE MODELER

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Abstract

Land use and land cover (LULC) dynamics are critical for understanding environmental change and implementing sustainable land management strategies. This study analyses LULC changes in the Sina River Basin, Maharashtra, India, over a 20-year period (2000–2020) using remote sensing data and the Land Change Modeler (LCM). In order to understand the extent and distribution of land use / land cover change, multi-temporal satellite imagery from LISS III (23.5 m resolution) was classified using Object-Based Classification techniques based on eCognition Developer software. The LULC classification had six main categories: agricultural land, barren land, fallow land, vegetation cover, built-up areas, and water bodies. The result suggests that the agricultural land increased from 30.77% (2000) to 68.97% (2010) and then decreased to 42.28% (2020), with a significant increase in fallow land. Barren land also fluctuated, decreasing from 37.78% in 2000 to 23.72% in 2010, then rising to 29.14% by 2020. These changes exhibit the agricultural base of the region and changing patterns of land abandonment. It shows that vegetation has been reduced from 11.95% (2000) to the lowest level of 1.28% in 2020 and is concerned about ecological degradation and biodiversity loss. This study emphasised the requirement of sustainable land management that might help to counterbalance the negative impact on diversity due to LULC changes as well as accentuate ecological equilibrium. Future research incorporating socio-economic dimensions could further investigate the underlying mechanisms of those LULC changes in this region.

Keywords: Land Use Land Cover (LULC) Change, Land Change Modeler, Crosstab Analysis, Sustainable Land Management Kolhapur

1. INTRODUCTION

Land use and land cover (LULC) changes are active components of global environmental change, the modification of which affects ecosystem services, biodiversity, and the sustainability of human livelihoods [1,2]. Land use refers to the ways in which humans occupy and manage the terrestrial Earth for different land use types such as agriculture, urban development, forestry, etc., while land cover is associated with the physical and biological material that overlies over the Earth surface, including vegetation, water bodies, bare soil, and artificial structures [3]. The global gross area of forest with a well-established growing stock is also shown in Table 1, which is essential for the advancement of scientific understanding on how to address serious global challenges such as climate change, deforestation, desertification, and land degradation [4,5].

Recently, the significant improvements and advancements in geospatial technologies like remote sensing (RS) and Geographic Information Systems (GIS) have actually transformed LULC monitoring and analysis for different spatial and temporal scales [6,7]. Combining high-resolution satellite imagery with powerful analytical tools has allowed researchers to detect spatiotemporal patterns of land cover transformation events at scale in a way that has never been achieved previously [8,9]. These methods are critical for understanding the proximate and underlying causes of land use changes and their environmental impacts, which in turn inform sustainable resource management and policy interventions following [10,11,12].

The perennial Sina River Basin (SRB), located in the semi-arid zone of southeast Maharashtra, India, is a classic example where agriculture-dependent land use systems are under threat due to land degradation and water stress [13,14]. The vulnerability of the basin is due to its fragile ecosystems and low water resource

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 UGC CARE Listed (Group -I) Journal Volume 11, Iss 10, Dec 2022

availability, which is associated with environmental degradations such as eroded soil, deforestation, and loss of vegetation cover [15,16]. The Sina River Basin, part of the Bhima, is crucial for regional agricultural productivity and socio-economic development due to its status as a tributary of the Bhima River system, although changes in land use patterns in several reaches present concerns over environmental sustainability [17].

India has experienced substantial LULC transitions due to rapid population growth, economic development, and urbanisation during the last few decades, which have greatly altered natural resources and ecosystem services [18, 19]. Major contributions to the global environmental degradation and socio-economic disparities are soil fertility, hydrological cycles, and biodiversity change. The growth of agricultural lands with deforestation and surrounding urban sprawl [20, 21] also affects the geo-hydrological regime. Thus, in order to make this choice suitable land management policies and conservation strategies, one must understand the spatio-temporal dynamics of land use changes [22, 23].

The aim of this study was to investigate the land use, land cover trends, and dynamics of Sina River Basin over a period of two decades (2000–2020) using freely available multi-temporal imagery data and the Land Change Modeler (LCM), an advanced tool that is used to simulate and predict potential future land cover changes at a landscape level [24, 25]. The research objectives include identifying area-specific changes in land cover, further investigating the local environmental condition and status of agricultural practices [26], such as spread or shrinkage of agriculture land [27], wasteland coverage expansion at a micro level deciduous vegetation change, along with being aware of environmental likings [28]. This study was targeted to conduct detailed LULC dynamics and their driving forces through the integration of geospatial analysis and ground truth observations for a larger area.

The importance of implementing sustainable land management practices to prevent the negative externalities of human-related damage such as soil erosion, lack of vegetation cover, and loss of critical ecosystem services [29,30,31] was also highlighted by this study. Results are intended to inform broader discussions on adaptation to climate change, conservation of biodiversity, and sustainable development in the semi-arid regions [32,33,34]. The study has provided empirical evidence and information for policymakers, stakeholders, and the local community in the planning and implementation of proper land use policies and for conservation purposes.

METHODOLOGY

This study uses a methodology that encompasses an effective coupling of remote sensing data, image processing techniques, and change detection practices through the Land Change Modeler (LCM). This approach allows us to deeply investigate the land use and land cover (LULC) changes of the Sina River Basin through 2000–2020 (a period of 20 years). It included a workflow for land cover transition quantification based on the use of remote sensing satellite data acquisition, from classification up to spatial analysis (using geoprocessing tools and mathematical formulations).

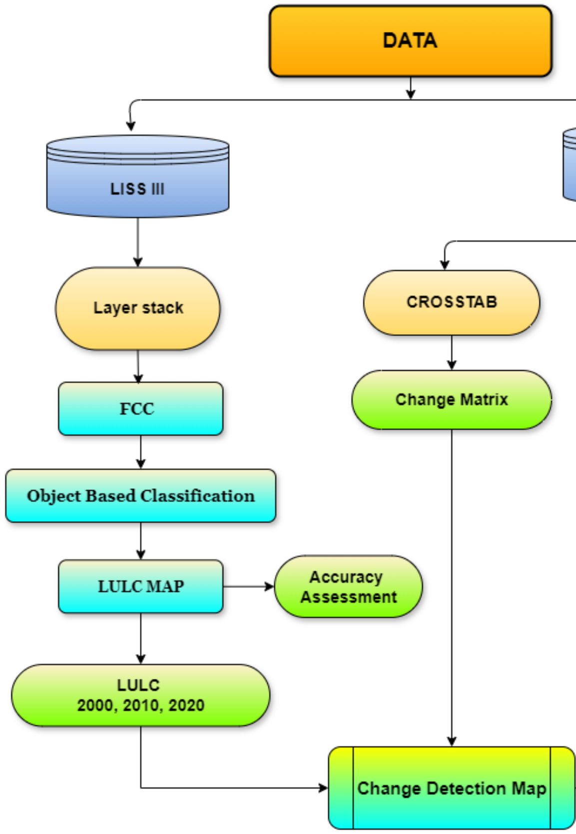


Fig.1. Methodology

1 Data Acquisition

The study obtained satellite image data of the Indian Remote Sensing satellite IRS via the LISS III sensor. The NSRC, Hyderabad, provided three multi-spectral images from the years 2000, 2010, and 2020, each with a spatial resolution of 23.5 meters. The image data has four spectral bands: green 0.52–0.59 µm, red 0.62–0.68 µm, near-infrared 0.77–0.86 µm, and short-wave infrared 1.55–1.70 µm, which is best suitable for land use classification. The temporally homogenous same months of the three decades obtained to reduce temporal and synchronic differences.

2 LISS III Data Processing

Layer Stack: Merging the LISS III images to multiband raster datasets for further analysis.

False Colour Composite (FCC): False colour images created by band combinations are better to discriminate between different land cover types.

Object-Based Classification: Pixels are combined into objects with comparable characteristics, which usually results in better classification accuracy compared to pixel-based methods.

LULC Map Generation: It includes an output as a LULC map of several years.

3 Classification and Land Cover Mapping

An object-based classification technique was used in order to achieve the desired classification accuracy and ensure that information both in terms of spectral and spatial was incorporated. The classification was performed using eCognition Developer Software to group neighbouring pixels that have similar spectral properties together into objects or segments that are homogeneous.

Training samples were collected from the ground truth data as well as historical records. The six different LULC classes identified in the study are agricultural land, barren land, fallow land, built-up area, vegetation cover, and water bodies.

4 LULC Change Analysis

Monitoring: This part relates to linking LULC data of various years for determining landscape alterations.

Land Change Modeler (LCM):

A distinct feature of the IDRISI software package is the option of performing land cover change detection with the Land Change Modeler (LCM). The LCM is a process that uses transition potential modelling as well as change quantification.

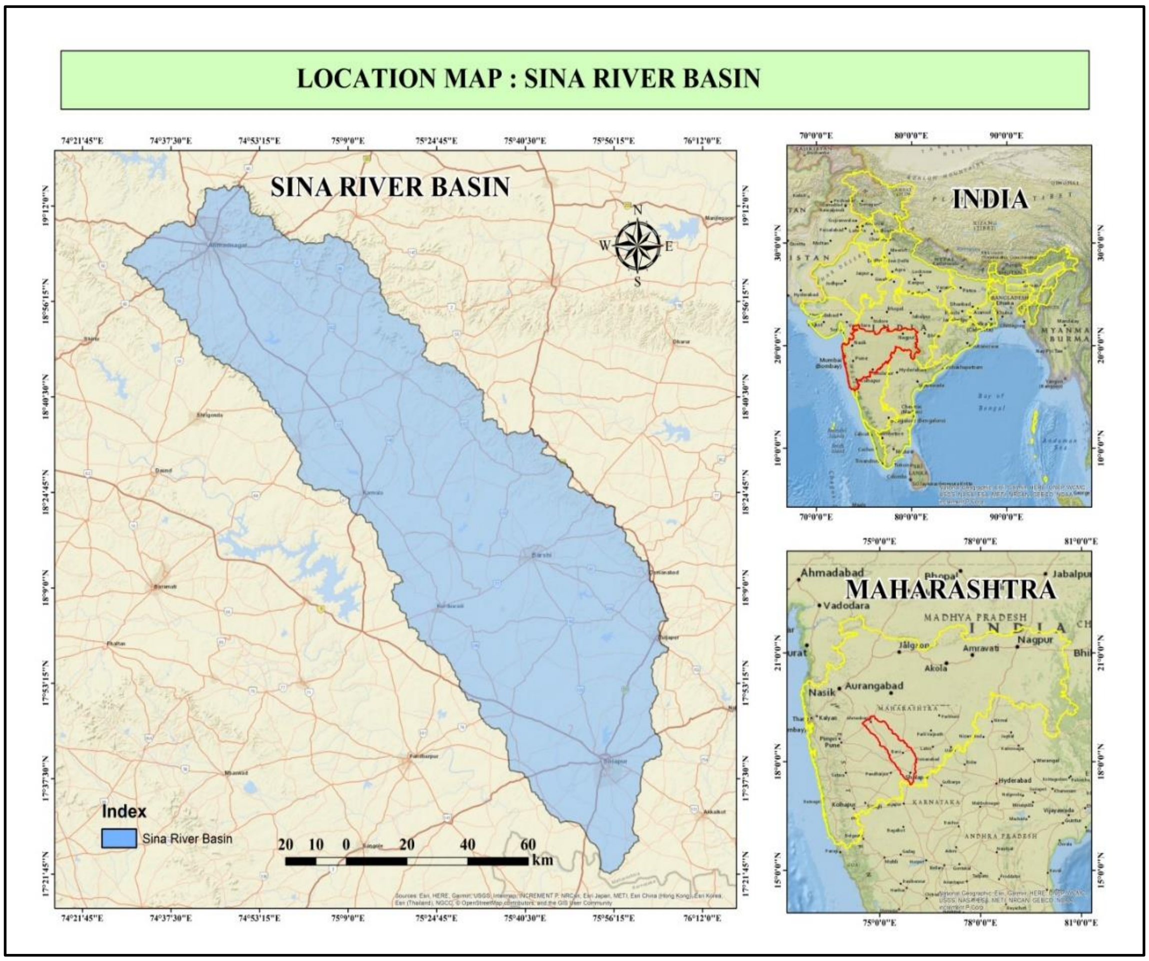
Cross-tabulation Analysis (CROSSTAB):

It serves as the cross-tabulation between different LULC datasets, which explains how the land has transitioned over time from one class to another. This method was used to examine the transitions between different LULC categories between the selected time intervals.

The entire study involves image preprocessing, classification, change analysis, and accuracy assessment. This methodology ensures that changes in land use over two decades are quantified and validated, supporting spatial planning and environmental management.

LOCATION OF STUDY AREA

Fig.2. Location of study area



Source: Based on Survey of India, SWAT Model

The Sina River basin is the focus of the current study. The study area is located in the southeastern part of Maharashtra. It extends between 18° 20’ 00” to 19° 20’ 00” North latitude and 74° 40’ 00” to 75° 20’ 00” East longitude. The Sina River, a left bank and large tributary of the Bhima River, originates near Ahmednagar city. It has two chief sources, one near Jamgaon about 20 km. west of the town of Ahmadnagar and the other near Jeur about 16 km. to its north-east. For a distance of roughly 55 km, the river forms a boundary between Ahmadnagar District on the one hand and Beed District on the other. The Sina River drains this area. The total area of the proposed study is 12356 km^2.

RESULTS AND DISCUSSION

1 Analysis of Land Use and Land Cover (LULC) Data (2000)

Fig.3. Land Use Land Cover Map 2000

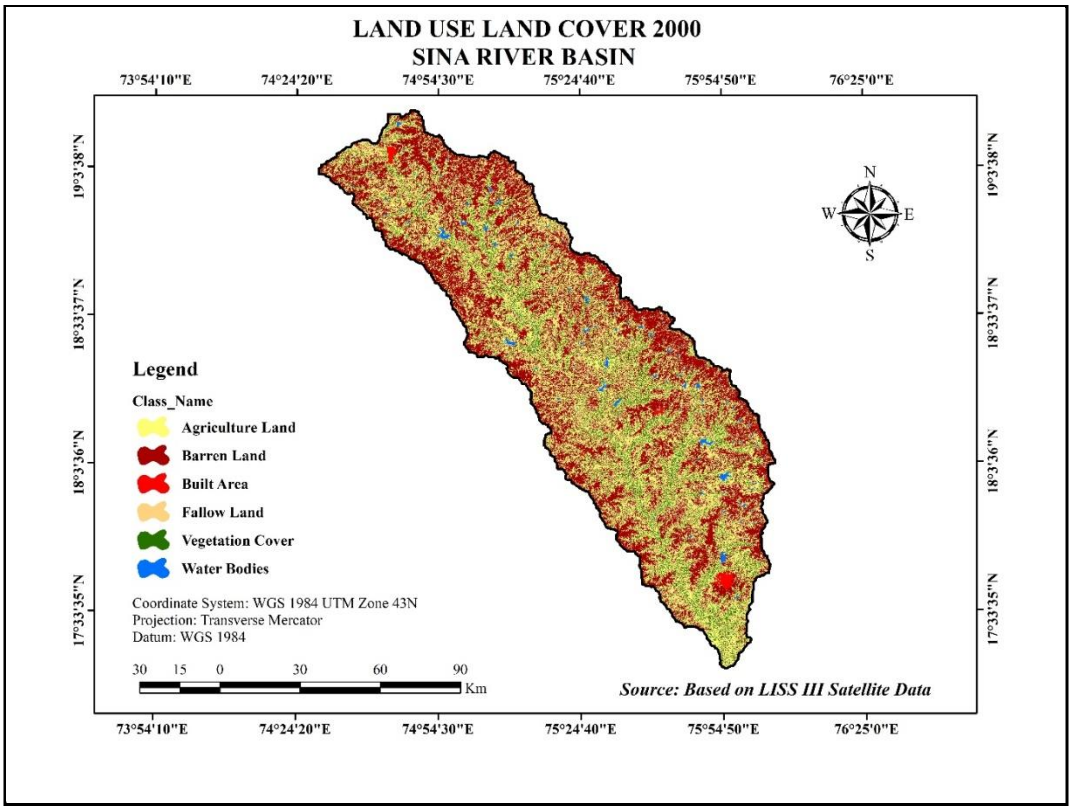


Table 1. Area of land Use Land Cover 2000

Class Name	Area in sq.km	Area in Percentage
Built-up	60.38	0.48
Barren Land	4669.31	37.78
Agriculture land	3801.83	30.77
Fallow land	2220.86	17.97
Vegetation Cover	1476.95	11.95
Water bodies	127.14	1.03
Total	12356.47	100

Source: Arc-GIS, Tool: Calculate Geometry

Table.2 Accuracy Assessment of LULC 2000

	Built up	Agriculture Land	Barren Land	Fallow Land	Vegetation	Water Bodies	Total (User)		
Built up	6	0	0	0	0	0	**6**	**Overall Accuracy 85 %**	**Kappa Coefficient 82.06%**
Agriculture Land	0	6	0	1	0	0	**7**		
Barren Land	0	0	6	1	0	0	**7**		
Fallow Land	0	0	1	6	0	0	**7**		
Vegetation	1	1	0	0	4	0	**6**		
Water Bodies	0	0	0	1	0	6	**7**		
Total (Producer)	**7**	**7**	**7**	**8**	**4**	**6**	**40**		

Source: LULC 2000 Map

Barren lands are the major land cover type in 2000 LULC, encompassing 37.78% of areas. So much barren land highlighted is in fact a large portion of unproductive or degraded land, which could be because natural conditions have led to this or due to anthropogenic activities such as deforestation and overgrazing. Agricultural land follows closely at 30.77%, showing how agriculture plays a significant role in the regional economy. The high share of land lying as fallow (17.97%) might be keeping in view the age-old practices wherein the land is left undisturbed for some time to regain moisture and fertility, but nevertheless indicates a possible scope of under-utilisation or potential wastage of arable land resources that can lead to higher productivity.

The percentage of the land area with vegetation cover is 11.95%, which seems low and suggests insufficient conservation of biodiversity and ecosystem services. Possible urban construction and water bodies of 0.48% and 1.03%, respectively, designate the sparse development of cities, as well as the rarity of drinking water sources. These land use patterns exhibit the viability of judicious land rehabilitation, agricultural improvement for sustainability, conservation measures, and strategic planning to positively influence environmental health and socio-economic growth in this region.

2 Analysis of Land Use and Land Cover (LULC) Data (2010)

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Fig.4. Land Use Land Cover Map 2010

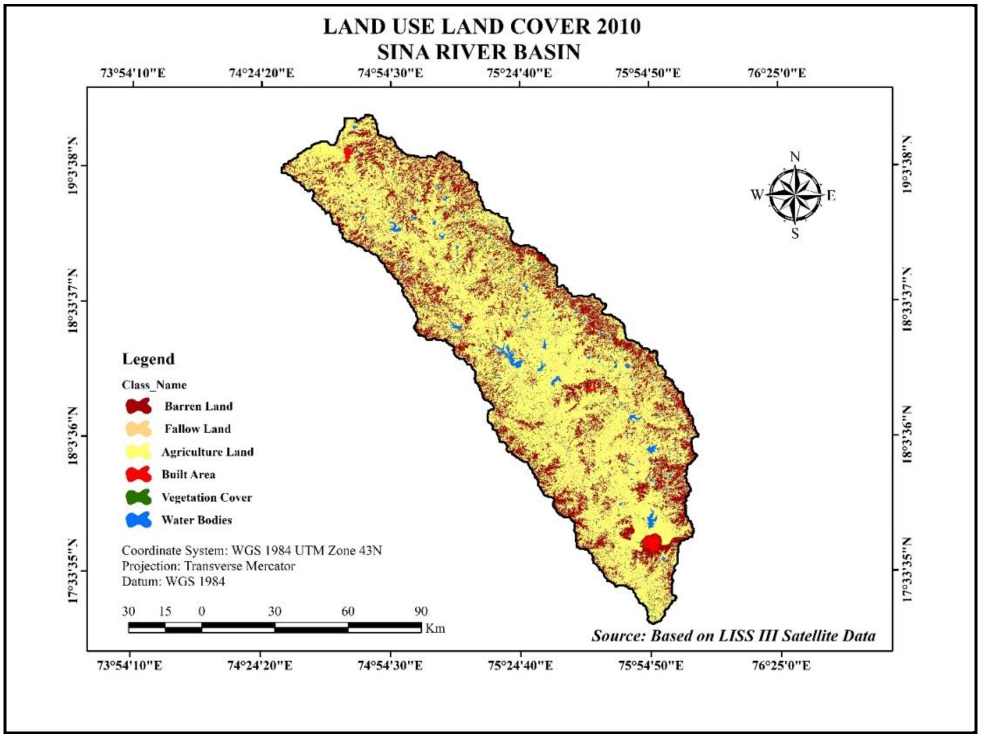

Table 3. Area of land Use Land Cover 2010

Class Name	Area in sq.km	Area in Percentage
Built-up	68.34	0.55
Barren Land	2930.94	23.72
Agriculture land	8522.71	68.97
Fallow land	441.92	3.58
Vegetation Cover	158.19	1.28
Water bodies	234.28	1.90
Total	**12356.47**	**100**

Source: Arc-GIS, Tool: Calculate Geometry

Table 4. Accuracy Assessment of LULC 2010

	Built up	Agriculture Land	Barren Land	Fallow Land	Vegetation	Water Bodies	**Total(User)**		
Built up	6	0	1	0	0	0	**7**	**Overall Accuracy 80 %**	**Kappa Coefficient 75.93 %**
Agriculture Land	0	5	0	0	1	0	**6**		
Barren Land	0	0	4	1	0	0	**5**		
Fallow Land	0	1	1	5	0	0	**7**		
Vegetation	1	0	0	0	5	0	**6**		
Water Bodies	0	0	0	2	0	7	**9**		
Total(Producer)	**7**	**6**	**6**	**8**	**6**	**7**	**40**		

Source: LULC 2010 Map

With 2010 LULC, a drastic change in land use codes was detected, while 68.97% is covered by agricultural land (Table 2). Such a huge increase compared to last year numbers implies considerable conversion of barren land, fallow land, and vegetation cover into agriculture use. The area of barren land deferred significantly and came down to 23.72%, which shows the unfruitful or underutilised tracts were brought by under cultivation. This shift in land use and the decrease in fallow lands corresponding to 3.58% and vegetation cover (1.28%) may indicate an increase in economic requirement, population pressure, or policy-based promotion of agriculture as a replacement process leading to maximum exploitation of land for agricultural productivity.

On the other hand, such a rate rose to 0.55% on built-up areas showing slight urban expansion. The area covered by reservoirs or water bodies increased to 1.90%, which could be due to the construction of irrigation schemes or building dams that aided the increase in agricultural activities. The changes in land use at the regional level reflect a structural emphasis on agriculture regionally and thus its vital role in the regional economy. This switch offers both opportunities and challenges for soil health and biodiversity alike since the decline of natural vegetation and fallow periods potentially means perpetual land degradation.

Table 5. Area of land Use Land Cover 2020

Class Name	Area in sq.km	Area in Percentage
Built-up	100.32	0.81
Barren Land	3601.3	29.14
Agriculture land	5225.3	42.28
Fallow land	3036.07	24.57
Vegetation Cover	159.2	1.28
Water bodies	234.28	1.89
	12356.47	**100**

Source: Arc-GIS, Tool: Calculate Geometry

3 Analysis of Land Use and Land Cover (LULC) Data (2020)

Fig.5. Land Use Land Cover Map 2020

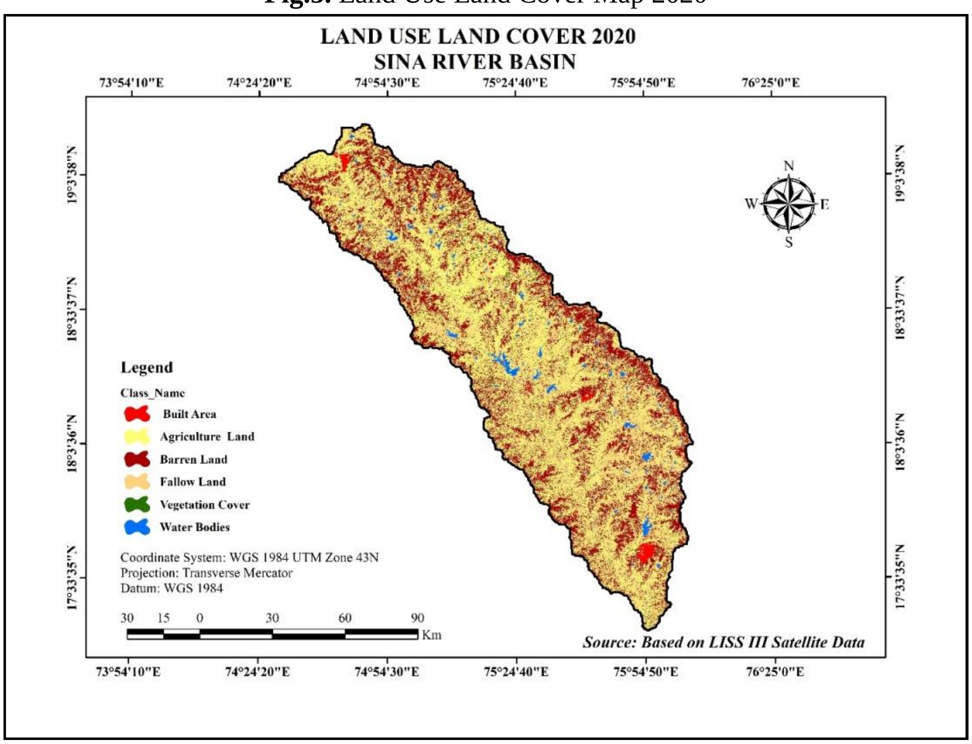

Table 6: Accuracy Assessment of LULC 2020

	Built up	Agriculture Land	Barren Land	Fallow Land	Vegetation	Water Bodies	Total (User)	Overall Accuracy 85 %	Kappa Coefficient 81.92
Built up	7	0	0	0	0	0	**7**		
Agriculture Land	1	7	0	0	0	0	**8**		
Barren Land	0	1	4	0	0	0	**5**		
Fallow Land	0	1	0	6	0	1	**8**		
Vegetation	0	2	0	0	4	0	**6**		
Water Bodies	0	0	0	0	0	6	**6**		
Total (Producer)	**8**	**11**	**4**	**6**	**4**	**7**	**40**		

Source: LULC 2010 Map

In 2020 LULC data, agricultural land has been significantly reduced to 42.28% (from 68.97% in 2010), while fallow land increased much to become 24.57 (up from only 3.58%). In this case, the likely reason for the shift is either abandonment of agriculture or adoption of fallowing practices in which fields are not used every year to allow soil fertility to recover. A rise in barren land to 29.14 percent could suggest issues like soil degradation, lower crop yield, etc., or even economic pressure not viable opportunities in agriculture and a fall back into landlessness. These changes indicate a shift in land use priorities and speak to issues of food security and sustainable agricultural practices within the region.

2.7 LAND USE LAND COVER CHANGE DETECTION (2000 AND 2010)

Fig.6. Land Use Land Cover change between 2000 – 2010

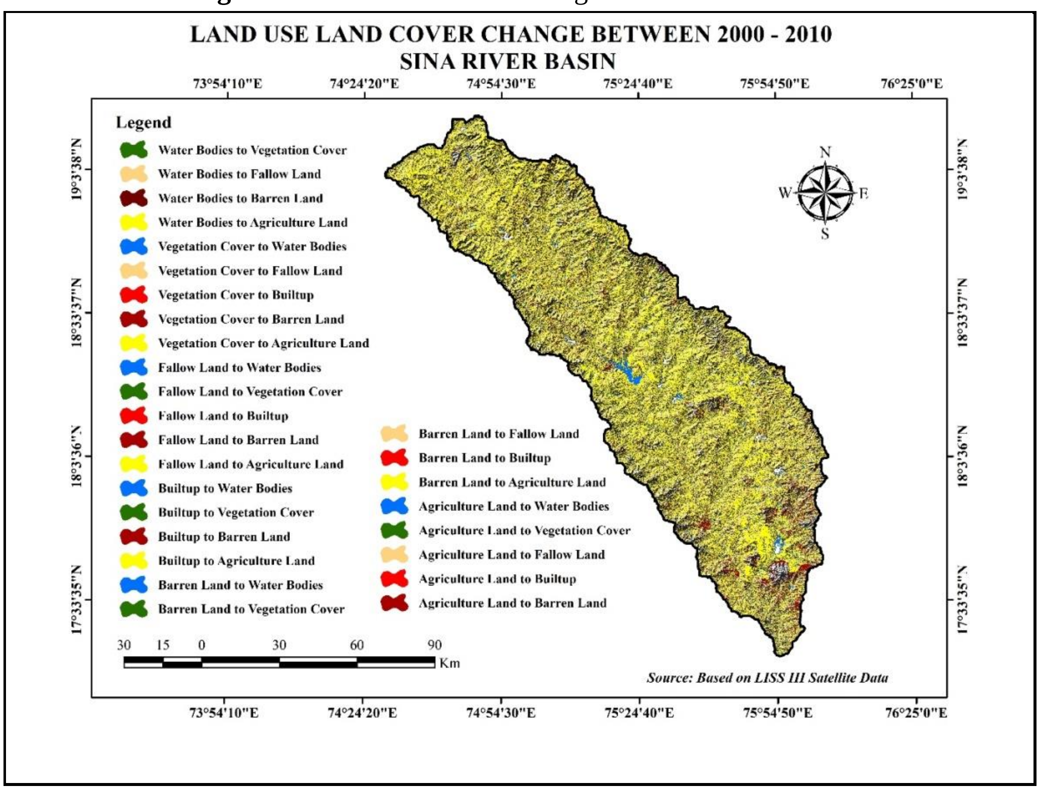

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Table 11. LULC area change (2000-2010)

Sr. No	Square kilometers	Legend
1	0.393984	Barren Land to Built-up
2	0.0144	Agriculture Land to Built-up
3	0.019008	Fallow Land to Built-up
4	0.001728	Vegetation Cover to Built-up
5	0.00864	Built-up to Barren Land
6	230.6949	Agriculture Land to Barren Land
7	315.1066	Fallow Land to Barren Land
8	54.46829	Vegetation Cover to Barren Land
9	1.594368	Water Bodies to Barren Land
10	0.013824	Built-up to Agriculture Land
11	2246.126	Barren Land to Agriculture Land
12	1796.75	Fallow Land to Agriculture Land
13	1304.475	Vegetation Cover to Agriculture Land
14	9.010944	Water Bodies to Agriculture Land
15	47.52403	Barren Land to Fallow Land
16	216.5253	Agriculture Land to Fallow Land
17	88.03814	Vegetation Cover to Fallow Land
18	6.7536	Water Bodies to Fallow Land
19	0.056448	Built-up to Vegetation Cover
20	1.928448	Barren Land to Vegetation Cover
21	149.9351	Agriculture Land to Vegetation Cover
22	0.073728	Fallow Land to Vegetation Cover
23	0.004032	Water Bodies to Vegetation Cover
24	0.007488	Built-up to Water Bodies
25	25.83475	Barren Land to Water Bodies
26	62.15558	Agriculture Land to Water Bodies
27	27.11232	Fallow Land to Water Bodies
28	11.59661	Vegetation Cover to Water Bodies

Source: Crosstab Analysis, Terraset

Fig.7. Gain and Losses between LULC 2000 and LULC 2010

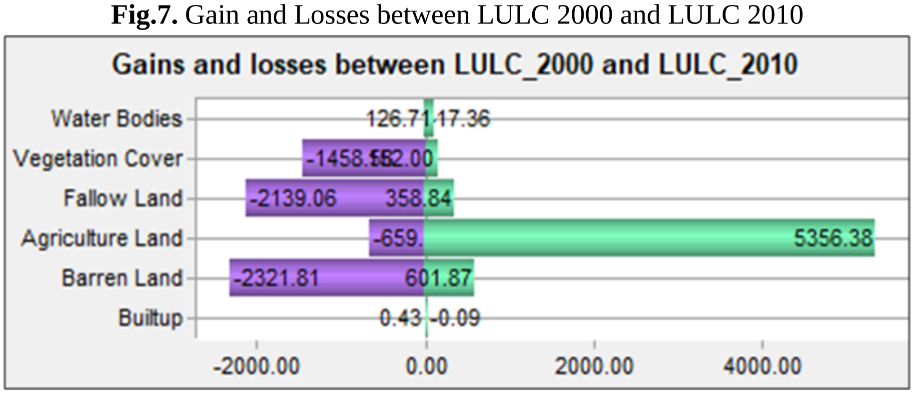

Fig.8. Net Change between LULC 2000 and LULC 2010

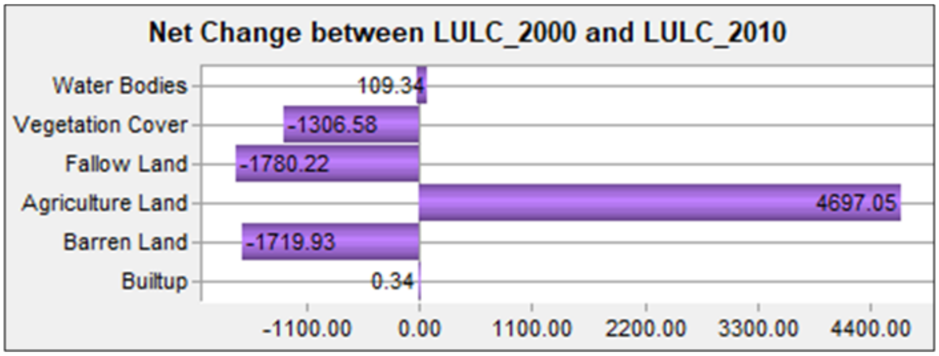

Table 7. Cross- Pixel tabulation (2000-2010)

Category	Built-up	Barren Land	Agriculture land	Fallow Land	Vegetation Cover	Water Bodies	Total
Built-up	117915	684	25	33	3	0	118660
Barren Land	15	4042458	400512	547060	94563	2768	5087376
Agriculture land	24	3899525	5491602	3119358	2264713	15644	14790866
Fallow Land	0	82507	375912	143954	152844	11725	766942
Vegetation Cover	98	3348	260304	128	13817	7	277702
Water Bodies	13	44852	107909	47070	20133	40589172	40809149
Total	118065	8073374	6636264	3857603	2546073	40619316	61850695

Source: Crosstab Analysis, Terraset

Note- Chi-square = 137998592.0000, df = 25, P-Level = 0.0000, Cramer's V = 0.6680

Table 8. Proportional Cross-tabulation

Category	Built-up	Barren Land	Agriculture land	Fallow Land	Vegetation Cover	Water Bodies	Total
Built-up	0.0019	0.0000	0.0000	0.0000	0.0000	0.0000	0.0019
Barren Land	0.0000	0.0654	0.0065	0.0088	0.0015	0.0000	0.0823
Agriculture land	0.0000	0.0630	0.0888	0.0504	0.0366	0.0003	0.2391
Fallow Land	0.0000	0.0013	0.0061	0.0023	0.0025	0.0002	0.0124
Vegetation Cover	0.0000	0.0001	0.0042	0.0000	0.0002	0.0000	0.0045
Water Bodies	0.0000	0.0007	0.0017	0.0008	0.0003	0.6562	0.6598
Total	0.0019	0.1305	0.1073	0.0624	0.0412	0.6567	1.0000

Source: Crosstab Analysis, Terraset

Kappa Index of Agreement (KIA)

Table 9. Using LULC 2010 as the reference image

Category	KIA
Built-up	0.9937
Barren Land	0.7638
Agriculture land	0.2957
Fallow Land	0.1337
Vegetation Cover	0.0090
Water Bodies	0.9843

Source: Crosstab Analysis, Terraset

Table 10. Using LULC 2000 as the reference image

Category	KIA
Built-up	0.9987
Barren Land	0.4560
Agriculture land	0.7733
Fallow Land	0.0252
Vegetation Cover	0.0009
Water Bodies	0.9978

Source: Crosstab Analysis, Terraset

Overall Kappa 0.65

The period of 2000–10 saw a large-scale transformation in land use characterised by massive conversions from uncultivated (Barren & Fallow) areas to net sown areas. The result was a net increase of 4,697.05 km^2 in agricultural land and only minimal growth of built-up surfaces that added up to 0.34 km^2 at the very same date (2—this time data refer not just to urban areas but also non-built-up lands). It seems that this shift results from more intensive agricultural activities, which may be ascribed to enhanced food demand or economic incentives and/or the advancement of farming technologies. The growth of agricultural land reflects a historical focus on improving the productivity base in agriculture that is likely to have positive economic benefits but may also impose competition for land resources.

In contrast, noteworthy net losses occurred in barren land (1,719.93 km^2), fallow land (1,780.22 km^2), and vegetation cover (1,306.58 km^2). The direct decrease in fallow/barren lands is matched with agriculture use purposes, though concern over the significant vegetation-cover loss remains. Habitat fragmentation, lower biodiversity, and poor soil protection are other adverse effects of decreasing vegetation cover. It demonstrates the necessity for sustainable land management techniques that account for agricultural expansion and still conserve ecological integrity, future biodiversity levels, and productivity of lands.

LAND USE LAND COVER CHANGE DETECTION (2010 AND 2020)

Fig.9. Land Use Land Cover change between 2010 – 2020

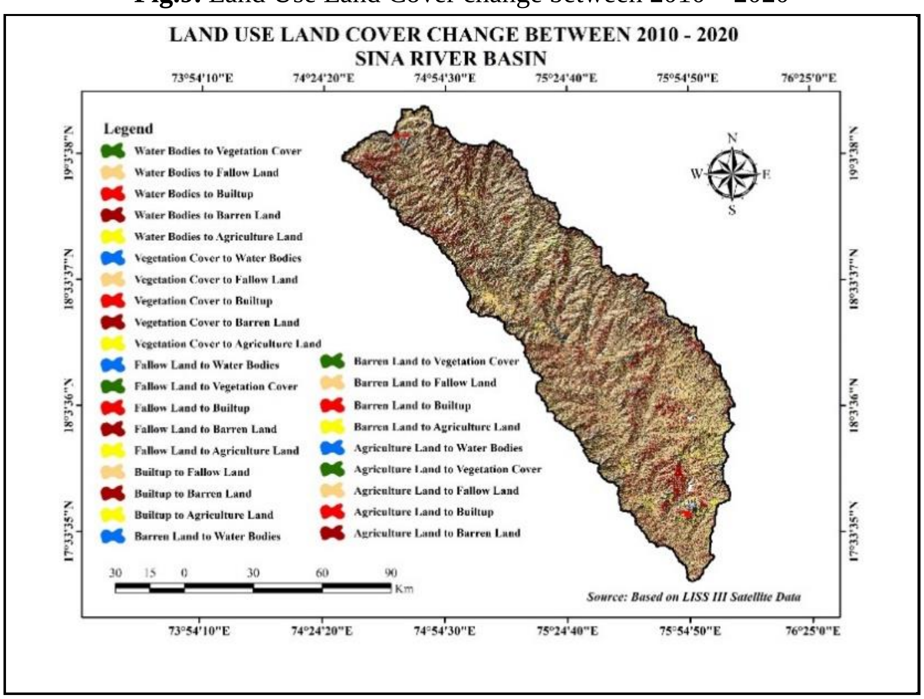

Table 16. LULC area change (2010 – 2020)

Sr. No	Square kilometres	Legend
1	20.957184	Barren Land to Built-up
2	10.737216	Agriculture Land to Built-up
3	0.158976	Fallow Land to Built-up
4	0.149760	Vegetation Cover to Built-up
5	0.046656	Water Bodies to Built-up
6	0.017280	Built-up to Barren Land
7	1530.245952	Agriculture Land to Barren Land
8	31.681152	Fallow Land to Barren Land
9	0.035712	Vegetation Cover to Barren Land
10	0.134208	Water Bodies to Barren Land
11	0.029952	Built-up to Agriculture Land
12	635.046912	Barren Land to Agriculture Land
13	165.782592	Fallow Land to Agriculture Land
14	0.247680	Vegetation Cover to Agriculture Land
15	0.261504	Water Bodies to Agriculture Land
16	0.010944	Built-up to Fallow Land
17	235.639296	Barren Land to Fallow Land
18	2554.631424	Agriculture Land to Fallow Land
19	0.149760	Vegetation Cover to Fallow Land
20	1.438272	Water Bodies to Fallow Land
21	0.010944	Barren Land to Vegetation Cover
22	0.283968	Agriculture Land to Vegetation Cover
23	0.023040	Fallow Land to Vegetation Cover
24	0.001728	Water Bodies to Vegetation Cover
25	0.032832	Barren Land to Water Bodies
26	0.705024	Agriculture Land to Water Bodies
27	0.975744	Fallow Land to Water Bodies
28	0.001152	Vegetation Cover to Water Bodies

Source: Crosstab Analysis, Terraset

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Fig.10. Gain and Losses between LULC 2010 and LULC 2020

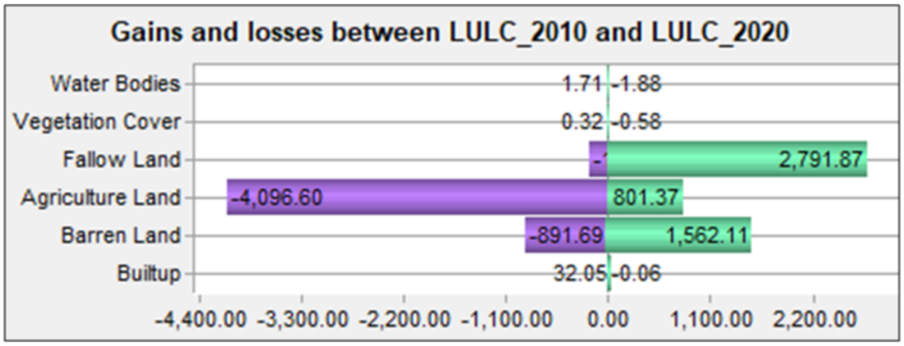

Fig.11. Net Change between LULC 2010 and LULC 2020

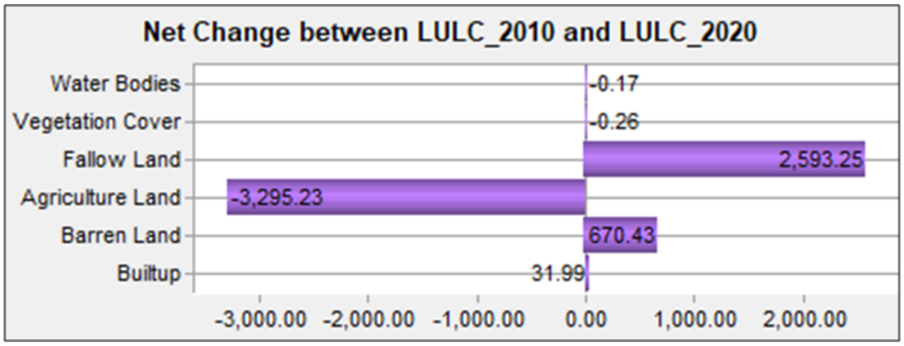

Table 12. Pixel Cross-tabulation (2010- 2020)

Category	Built-up	Barren Land	Agriculture land	Fallow Land	Vegetation Cover	Water Bodies	Total
Built-up	118559	36384	18641	276	260	81	174201
Barren Land	30	3539308	2656677	55002	62	233	6251312
Agriculture land	52	1102512	7678707	287817	430	454	9069972
Fallow Land	19	409096	4435124	422113	260	2497	5269109
Vegetation Cover	0	19	493	40	276688	3	277243
Water Bodies	0	57	1224	1694	2	40805881	40808858
Total	118660	5087376	14790866	766942	277702	40809149	61850695

Source: Crosstab Analysis, Terraset

Chi-square = 181048784.0000, df = 25, P-Level = 0.0000, Cramer's V = 0.7651

Table 13. Proportional Cross-tabulation (2010 - 2020)

Category	Built-up	Barren Land	Agriculture land	Fallow Land	Vegetation Cover	Water Bodies	Total
Built-up	0.0019	0.0006	0.0003	0.0000	0.0000	0.0000	0.0028
Barren Land	0.0000	0.0572	0.0430	0.0009	0.0000	0.0000	0.1011
Agriculture land	0.0000	0.0178	0.1241	0.0047	0.0000	0.0000	0.1466
Fallow Land	0.0000	0.0066	0.0717	0.0068	0.0000	0.0000	0.0852
Vegetation Cover	0.0000	0.0000	0.0000	0.0000	0.0045	0.0000	0.0045
Water Bodies	0.0000	0.0000	0.0000	0.0000	0.0000	0.6597	0.6598
Total	0.0019	0.0823	0.2391	0.0124	0.0045	0.6598	1.0000

Source: Crosstab Analysis, Terraset

Kappa Index of Agreement (KIA)

Table 14. Using LULC_2020 as the reference image

Category	KIA
Built-up	0.6800
Barren Land	0.5273
Agriculture land	0.7984
Fallow Land	0.0686
Vegetation Cover	0.9980
Water Bodies	0.9998

Source: Crosstab Analysis, Terraset

Table 15. Using LULC_2010 as the reference image

Category	KIA
Built-up	0.9991
Barren Land	0.6615
Agriculture land	0.4365
Fallow Land	0.5085
Vegetation Cover	0.9963
Water Bodies	0.9998

Source: Crosstab Analysis, Terraset

Overall, Kappa 0.72

From 2010 to 2020, there were marked land use/land cover changes, specifically by the conversion of agricultural land to fallow, which covered a total area of 2554.63 km2 [34]. Such a substantial alteration could be read as less farming, potentially an era of soil exhaustion and financial difficulty, or a logical step of letting the land remain idle and allowing it to nourish due to resting. At the same time, 635.05 km² of barren land was converted into agricultural land, reflecting an attempt to bring hitherto non-productive areas under cultivation.

Net gains were reported in fallow land (2,593.25 km²), barren lands (670.43 km2), and built-up areas as a whole (31.99km²). More extensive pasture use may be indicated by increased fallow or barren lands, which suggest decreasing land condition due to anthropogenic pressures, and/or changing practices with more reliance on resting these areas rather than continuous cultivation. Built-up areas can further grow in the 2020s, due to an ongoing wave of urbanisation and infrastructure development. On the other hand, there were net losses in agricultural land (3,295.23 km²), vegetation cover (0.26 km²) and water bodies (0.17 km²).

The decrease in agricultural land may lead to a reduction in food production, and worries about national food security could arise; small declines of vegetation cover or water bodies are potential threat for biodiversity values or changes on the availability of water resources. These changes highlight the need for sustainable land management strategies to reconcile agricultural demands with environmental interests and address root causes for lands being taken out of productive use.

CONCLUSION

The land use and land cover change (LULC) sequence between 2000 and 2020 shows dramatic shifts in the local landscape. From 2000 to 2010, a notable transition was noted as large stretches of deserted and fallow lands were turned into farmland since, by 2010, agriculture had become the primary land use, accounting for 68.97% of all uses. This expansion means ever-more concentrated agricultural activities, possibly made necessary by greater food demand, extrapolations of economic incentives, or even advancements in agro-technology. Yet such growth, at the cost of vegetation cover and the traditional fallow unjustifiably harmed, is leading to worries about biodiversity loss, soil degradation, and the sustainability of ecosystem services. In the future, does this issue need more attention, particularly from eco-systemologists concerned with the implications of man's greed upon our national environmental heritage?

On the other hand, the period from 2010 to 2020 saw a significant decrease in agricultural land to 42.28% and an increase in fallow land up to 24.57%. These rotations may indicate past agricultural abandonment, soil depletion, or a planned fallowing to allow soils to recharge their nutrient status. At the same time, a separate increase in unproductive land suggests widespread problems like soil degradation or agricultural abandonment. Moreover, the modest and consistent increase in built-up areas may indicate incremental urbanization. This highlights the importance of integrated land management approaches that deliver sustainable farming, restore degraded lands, and protect natural vegetation actions in maintaining long-term environmental health as well as socio-economic development.

Between 2000 and 2020, the LULC underwent distinctly major changes with significant environmental impact. The rapid increase in this agricultural land to 68.97% already by 2010, mainly at the expense of vegetation cover and traditional fallow practices, led to concerns about a loss of biodiversity, soil degradation, and sustainability of ecosystem services. A decrease in agricultural land to 42.28% and an increase in fallow lands amounted to 24.57% between 2010–2020 suggest challenges such as land degradation, agriculture abandonment, and fertility restoration through strategic crop rotation techniques. These trends are confirmation of the need for integrated land management practices that encourage sustainable agriculture, restore imperilled lands, and protect natural vegetation.

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